FIRST ANNUAL REPORT

OF THE

STATE BOARD OF

HEALTH, LUNACY, AND CHARITY

OF MASSACHUSETTS.

1879.

SUPPLEMENT

CONTAINING THE

REPORT AND PAPERS ON PUBLIC HEALTH.

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STON.

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ALL RIVER.

CAMBRIDGE.

AMHERST.

LAWRENCE.

LOWELL.

WORCESTER.

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1880.

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1879.

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Dr. BOWDITCH resigned his position since the close of the year, and was succeeded by DAVID L. WEBSTER, Esq., of Boston, Dr. DAVIS becoming chairman of the Health Department.

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GENERAL REPORT.

The Pollution of Streams.

The Westfield River basin, having an area of 529.28 square miles, and a population of 46 to the square mile, has been examined, in continuation of the investigations begun in 1875. It is a rural district, containing 22 towns with 24,365 inhabitants, estimated from the census of 1875; the largest, Westfield, containing 8,431 people in 1875, alone having a water-supply,[1] and a population exceeding 1,600, within the drainage-area of the Westfield River. There are 12 paper-mills, 2 tanneries, 2 cloth-mills, one dress-goods mill, and one cotton-mill, employing 1,130 hands, from which more or less refuse reaches the river, which has an average dry-weather-flow calculated to be from 343,872,921 gallons in 24 hours to the least recorded quantity of 35,547,431 gallons. The river is not, and is not likely to be, used as a source of domestic water-supply; and it is sensibly polluted only by the spent bark from a tannery in North Becket, and from mills in Middlefield and Huntington, so far as to be a source of some complaint or inconvenience. More filth is cast into the stream, however, than is necessary, and, in the case especially of human excrement, to an avoidable degree. There are no town sewers, although much needed in Westfield, except for a small part of that town and for portions of West Springfield. During its course from a small peaty stream in Cummington, the Westfield River gains a considerable amount of inorganic matter and chlorine, partly from solution of salts in the soil in and near its bed, and in small part probably from the refuse cast into its waters from mills, surface drainage, drains, privies, &c. The organic matter disappears to nearly the same extent: it is evidently largely

[1] West Springfield has only a partial supply.

of vegetable origin, is only slightly increased by human agency, and is lost to observation probably as much through the influence of dilution, as the stream grows larger, as by oxidation. It is not likely that legislative action will be necessary to keep the Westfield River clean; indeed, at the present time it is more important to sewer the town of Westfield, from which a greater, but probably not harmful, contamination of the river would result. The filth which can be kept out of the stream without undue trouble, and is now discharged into it, consists in refuse and excrement from mills.

In the Merrimac River, the sewage of Lowell is diluted with from 600 times to 1,000 times its volume of water, and then flows a dozen miles to Lawrence, much of the refuse from the mills acting as a precipitant and disinfectant to it. It is not surprising, therefore, that with the uncertain and incomplete methods of chemical analysis we are unable to prove pollution of the river, even by the filth of a city of 50,000 inhabitants. The water-supply of Lawrence, although at first supposed to come from the river, probably is collected largely in the filtering-basin from the ground-water of that drainage-area.

By a fire in chemical works, June 2, 1879, 50 tons of oil of vitriol (estimated), together with salt-cake and other chemicals, found its way into a brook about three feet wide close by. June 7, A. M., the acidity was expressed by 1.74 parts of sulphuric acid in 100,000 parts of water, and by 0.37 three miles and a half below; disappearing so that the water reached its natural alkalinity June 15, becoming slightly acid again June 19, and remaining alkaline after June 30. The acid was not observed at any time in Mystic Pond, from seven to eight miles below the works. This disappearance of the acid illustrates much that has been said of the alleged "self-purification" of streams.

Food.

Two papers are offered upon this subject. The first shows that by the examination of those portions of the flesh of swine most likely to be infected with trichinæ,—namely, the pillars of the diaphragm,—154 out of 2,701 were found trichi-

nous, or 5.7 per cent: of a single lot of 109 examined by the Secretary of the Board, there were none found trichinous, the highest percentage got by the writer being 13.89. Dr. Billings's results are confirmed by investigations in Erie and Chicago. During the period of five months, when his examinations were made, he probably did not inspect more than one-hundredth of the hogs slaughtered near Boston, so that it might easily happen that certain lots not seen by him were much more free from trichinæ than those examined. Rats are shown to be particularly infected, but the source of infection for swine is not yet understood. Directions for examining pork, descriptions of the disease trichinosis, with remarks on the degree of its prevalence and on its history, desirable regulations to prevent communicating trichinæ, and methods of rendering trichinous meat safe (a heat of 140° F. throughout the flesh), are given in the paper very fully. As raw and under-done pork is not so largely eaten here as in Germany, trichinosis is very far less common.

Mrs. Richards has examined at the Woman's Laboratory of the Massachusetts Institute of Technology 160 samples of cream of tartar, 93 of soda, 33 of baking-powders, and 75 of sugar, from 141 dealers in 40 cities and towns from various parts of the State, as well as 25 samples of flour from 11 towns. The samples were purchased from retail dealers, "without any suspicion on their part that the articles were to be tested." In no case was there found any evidence of mineral additions to the flour.

None of the sugar (powdered 34, fine granulated 26, light brown 8, dark brown 5, cut loaf 2 samples) contained tin.

Of the white sugars, not one gave re-actions for chloride of calcium; one only out of 55 gave any indication of glucose, and that in a faint degree. Of the 13 brown sugars, 7 gave slight re-actions for chloride of calcium. The worst two of these were analyzed, and gave respectively three-tenths and four-tenths of one per cent of chloride of calcium and chloride of sodium, or salt, a quantity that might have been derived from the water used in the process of manufacture, and too little to do the least harm. Of the 13 brown sugars, 6 gave traces of reducible sugar, or glucose,

and three only gave considerable amounts, 8.3, 8.6, and 11.1 per cent respectively. Two of the three samples were of the darkest color found, and undoubtedly contained some molasses, which always carries a large per cent of reducible sugar, or glucose, formed in the process of the refining of the cane-juice. The glucose is not a harmful adulteration, and it is by no means certain that it is less valuable for food than sugar.

Of the 93 samples of soda, 19 were nearly chemically pure; 43 were good; 25 contained from 3 to 16 per cent of chloride and sulphate of sodium, — not injurious impurities, but deteriorating the value of the powders, and indicating want of sufficient care in their manufacture. The cream of tartar showed considerable evidence of adulteration in 42 per cent of the samples. Fifty-six contained large quantities of ground gypsum, which is certainly not wholesome, and which makes poor bread. Of the 33 baking-powders, 24 contained only an excess of flour or starch; 8 contained alum; 5, ammonia. A large excess of starch, in several cases amounting to 45 per cent, was found in some samples.

Water-Supplies.

Professor Wood's paper on the character of the water-supply furnished by Fresh Pond shows clearly the impossibility of providing pure drinking-water to large cities without much more careful supervision and control over ponds and streams than has been hitherto customary in this State. The danger from pollution through a contaminated stream running into a water-supply, and also by a large amount of filthy water overflowing meadows or manured land within the watershed of a storage-reservoir, is one to which the inhabitants of several of our cities are now exposed. This is the special subject treated by Professor Wood, the care and thoroughness of whose methods and investigations cannot be too highly commended.

The observations on Fresh Pond, by Professor Nichols, open a field for investigation with reference to the circulation in ponds, and the amount of impurity present. Examinations of the water of Mystic Pond, by the same writer, introduce, for the first time in these reports, Frankland's method of determination of the "organic carbon" and

"organic nitrogen," as a means of indicating the difference between organic matter of vegetable and of animal origin in surface waters, — a department of analytical chemistry which still has its future.

Mr. Fteley has carefully studied the appearance and temperature of the water when affected by the algæ which appeared in one of the storage-basins of the Boston water-supply in 1879, — a species of the *Nostoc* family of plants, resembling microscopically the *Clathrocystis*, which has been a source of so much trouble in Mystic Pond for several years past. Professor Farlow's paper on some impurities of drinking-water caused by vegetable growths, especially the *Cœlosphærium* observed by Mr. Fteley, and the *Clathrocystis* and *Anabæna* of the Mystic basin, will be of the greatest value to engineers, sanitarians, and water-boards, as dealing with a matter hitherto little known, and to the public, in relieving them of needless anxiety with regard to danger to health from these plants. The medical correspondence from thirty-three physicians tends to show that the plant acts mechanically chiefly, perhaps like unripe fruit, when affecting the health at all, in causing diarrhœa; but that the filtered water is harmless.

Country Drainage.

One hundred and fifty summer houses, including hotels, boarding-houses, and private dwellings, examined by Mr. Bowditch, were almost without exception more or less objectionable on the score of danger to health. This danger was found to be due chiefly to stinking emanations in the air, to the products of decomposition of excrement conveyed to dwellings by drain-pipes, and to the contamination of well-water from the proximity to vaults and cesspools. Although an abundance of pure air in the majority of these cases prevented any thing like an epidemic, or even widely-extended illness, yet it is difficult to trace in transient visitors any sickness contracted while away from home for their health; and it is not supposed that any thing more is caused by the bad drainage commonly found in the country than a *risk* of disease. .Typhoid-fever and diphtheria are more fatal in the rural districts than in cities supplied with

water-supplies and sewers. That a great amount of the mortality from these sources can be prevented by better drainage, has been too firmly established by experience, in our own State and elsewhere, to longer admit of any doubt; although it is admitted that we are still ignorant how far it is possible to drink or breathe in human excrement without incurring disease, to what degree of dilution or oxidation it is necessary to have it reduced, exactly wherein lies the danger from the poison of specific diseases, and precisely when and where the danger begins. That polluted drinking-water is often used without apparent harm, is well known; that there is *always a risk*, no matter how great or how small, in drinking it, is now demonstrated, *the only safe rule* being to have wells so situated that they *cannot be polluted;* or, to put the proposition in another form, to so arrange privies, cesspools, &c., that they *cannot contaminate the sources of water-supply.* If this were done, and if proper directions were carried out, with tight cesspools, emptied by some of the odorless excavators for the liquid refuse, and with proper removal of garbage and swill, all reasonable requirements of health and decency might be readily filled at no extravagant cost.

It has been suggested by residents of Oak Bluffs that a water-supply be introduced by pumping from deep wells, and that sewerage be adopted, either general, or for particular localities, with underground sewage-irrigation. The soil is so light as to render such a plan less expensive than private wells and cesspools. From a sanitary point of view, too, it is the best possible solution of the difficulties in the case.

SEWERAGE.

Mr. Clarke's directions have been prepared and revised with great care, in order to supply to the cities and towns of Massachusetts some general rules which experience in various parts of the State has clearly shown to be very much needed. By a careful comparison of the opinions of the leading engineers of experience in sewering cities, both in this country and in Europe, it is evident that the directions given correspond with the general practice here and abroad. There has been for some years a feeling, especially on the part of a few English and American engineers, that under

certain circumstances it is desirable to separate the rainfall from the sewage proper. That has recently been done in Oxford, Eng., where the city was forbidden to discharge into the river, and where only a small amount of land being available for irrigation, it was absolutely necessary to restrict to the smallest possible quantity the amount delivered on the soil by the sewers. In the year or two of its trial, it has thus far proved successful; Oxford being a small city of 21,016 inhabitants by the census of 1871. In Memphis, also, the usual system of sewerage has been utterly beyond the financial resources of the city, and the pressing demand for removal of the filth stored up for so many years in the soil of that city of fifty thousand people fully justified the experiment of attempting to get ready for another season of heat, and possible yellow-fever, by a method of sewerage which, no doubt, can be made thoroughly efficient in removing filth. For large cities, however, and in places of moderate size where time and poverty are not pressing, there are other objects necessary in sewerage beside removing the sewage proper. The rainfall is to be disposed of, and the soil is to be deprived of its superfluous moisture. For, as remarked by the late Mr. J. P. Kirkwood, in the Seventh Report of the Massachusetts State Board of Health, p. 152, the neglect of deep-soil drainage in the country at farm-houses, isolated dwellings of any kind, or villages, must be the cause of more sickness than any defects in the condition of the waters used there. To construct three systems of sewers for these purposes is unnecessarily expensive; and to allow the surface-water to flow off by superficial carriers is very inconvenient, except in small places. Provision for removing filth alone by sewers commonly delays, for a long period, deep drainage and drying of soil and cellars.

Typhoid-Fever.

Dr. Abbott's paper indicates the surroundings of a considerable number of cases of typhoid-fever observed by several physicians, in support of Liebermeister's formula, that, the more human filth there is stored up in a given place, the more *chances* there are of typhoid-fever, *when the other factors of the disease are present.*

Dr. Amory and Dr. Sabine report 42 cases of typhoid-fever,

22 of various forms of fever thought to be typhoid, in Brookline in 1879, and six deaths, indicating probably an amount of that disease in the town unprecedented in the last fifteen years. In 1864, 1870, and 1875, considerably larger numbers of deaths from typhoid-fever were reported than in the other years; while at least one was returned in every year except two, since 1864. An inspection of the death-returns, however, shows such manifest errors and omissions that no further conclusion can be drawn from them, except that typhoid-fever is a recognized cause of death in the town, and that its prevalence periodically increases.

The map shows the localities invaded; the dotted line indicating the old course [1] of the brook, the broken line the new,[1] from the point at which it passes out from under the railroad-track near the station, to its discharge into Muddy Brook. At the point S is the crossing of the sewer, causing the filth-overflow into the brook, as mentioned in Mr. French's report. The new intercepting sewer follows the line of the railroad, and empties into Charles River: the letters *a*, *b*, and *c* represent the northerly limits of the sewered area. The sanitary condition of that low portion of the town, for years noted as productive of disease, where the least careful and most overcrowded inhabitants live, and near the houses where the most cases of fever occurred, is described in the following report: —

BROOKLINE, April 16, 1880.

DR. C. F. FOLSOM,
Secretary of the State Board of Health, Lunacy, and Charity.

Dear Sir, — I hereby respectfully submit to you the following statements concerning the contamination of the water-courses in the vicinity of Brookline station. I would say, in the way of preface, that it was difficult to learn the absolute facts in every instance, without more labor than I supposed the necessity of the case required. The people whose lands abut on the brook channels, as a rule, were very averse to admitting what the facts were, as regards the drainage of their lands; and in a few instances I have therefore to report from indications rather than from actual knowledge. In many cases where the vaults were tight, they were full to overflowing with fœcal matter.

The number of privy-vaults which discharge fœcal matter into the old brook channel before reaching that part of Muddy River lying be-

[1] These open streams are "common sewers" by act of the legislature, accepted by the town.

tween Brookline Avenue and Downer Place is 30, over which are placed 54 privies The length of channel is about 2,200 feet.

The number of privy-vau'ts which discharge into the artificial channel along the railroad, from the railroad station to Aspinwall Avenue, a distance of about 1,800 feet, is two, over which are placed 23 privies.

Of the first-mentioned lot, 27 privies are located either over or so near the brook that the vaults retain no fœcal matter. Of the second lot, four privies are thus situated.

Of the first-mentioned lot, twenty-seven privies are more or less remote from the brook; but nearly all are within a distance of ten feet.

Of the second lot, one vault, over which nineteen privies are situated, is only separated from the brook by a stone wall which allows liquid sewage to escape into the brook.

With the exception of those privies situated over the brook, and the one vault with nineteen privies, the vaults are arranged to overflow into the brook.

The condition of the brooks is very filthy, especially the one lying between Brookline Avenue and Downer Street, but very much less so than they will be in the summer when the flow of water becomes smaller than it now is.

The main sewer laid by the town of Brookline is so arranged at the crossing of the brook channel, that a very considerable contamination of the water-course must arise from the sewage expelled from the sewer at every incoming tide.

Respectfully yours,

ALEXIS H. FRENCH, C.E.

Some of the above-mentioned privies are emptied from time to time, but much fœcal matter gets into the brook, and the much-talked-of Bayou Gayoso in Memphis was no filthier at the close of the yellow-fever epidemic than this brook in Brookline when I inspected it in April of this year, although then much fuller of water than in the summer months. The regulations of the former board of health to keep the stream clean have evidently not been carried out.

One of the better houses, on high land, inspected in March of this year, and not included in the list given in the report where the sanitary condition was described, was found to be in a very bad state from a broken drain. The drain was a *semicylinder of brick, built twenty years ago;* and the cement had so dropped out of its place between the bricks that the *sewage soaked down close to the outside of the cellar-wall*, and thence through the foundations *into the cellar*, spreading about its floor. This had been going on for *an unknown period.*

By the introduction of the intercepting sewer in 1878 and the lowering of the water in the ground thereby, a layer of soil somewhat affected by the filth from cesspools previously in use, was exposed to the air, allowing a certain amount of decomposition, which Pettenkofer and his school consider the most important factor in the production of typhoid-fever.

The water in Brookline was at some times in the year observed to be quite bad at some houses, while at the same time nothing uncommon was noticed in its condition in other families, until finally, when the fact was ascertained that so much swamp-water was used, people generally discontinued drinking it, as a wise precaution advised by the local board of health, until the improvements were carried out which have removed all objections to its use. The engineer took great pains to pump off several hundred gallons of water every Monday, and throw it away, and always to convey it to the storage-reservoir only when it looked pure. Of the forty-two cases of typhoid-fever, there were seven in which mention was made of the appearance of the water used for drinking. Two used polluted well-water; in three the public water seemed good, and in two bad. A number of families had complained of the water before any typhoid-fever occurred.

Diarrhœal diseases were not uncommonly prevalent during the year. In only one of the seventeen houses whose sanitary condition is given, can it be said that there are not conditions of filth if we consider ordinary cesspools objectionable, while parts of the town are in the highest degree nasty. The mere existence of a cesspool, unless looked after with extraordinary care, furnishes opportunities for filth-infection, until it has been abandoned long enough to allow the soil to become aërated and pure again. A common privy is of course worse.

At the present time, science has not yet gone far enough to say with precision what are all the factors in the production of typhoid-fever. That filth, or something originating in filth, is a prominent factor is almost universally conceded. How far nastiness, the condition of the drinking-water, and the lowering of the soil-water, contributed to the epidemic in 1879 in Brookline, is a matter very difficult to determine.

In Fairhaven, every individual, comprising eight persons, who drank water from a certain well last September, became ill of typhoid-fever. This well (see pp. 270 *et seq.*) was shown to have been probably contaminated with fœcal matter containing the typhoid-fever poison, although filtered through a hundred feet of gravel so as to remove all the insoluble filth and to oxidize a great part of that which is ordinarily dissolved. This case apparently confirms the now general belief that the specific poison of typhoid-fever is capable of enormous multiplication in the human body, and that when discharged with the excrement it is capable, under certain conditions not fully known, of transmitting the disease to such susceptible persons as take it in with air inspired, or with the food, in such a state as to render it capable of its specific action.

A large number of cases might be cited to show that this peculiar specific poison is conveyed in water, air, and gases, notably sewer-gas, and in the air exhaled from soil in which the dejections from typhoid-fever patients have been deposited, — possibly from any organic matter decomposing under certain conditions.

The air in the soil, too, even very many feet deep, is subject to constant variations of pressure, &c., and is always changing. The amount of carbonic acid formed by decomposition going on in the earth and driven into the air, together with other results of putrefaction and decay, is at the warm seasons of the year enormous. This chemical and physical change goes on most rapidly in those portions of the soil which are alternately wet and dry from changes in the level of the soil-water, and by many leading authorities is considered an essential factor in the production of enteric fever.

It has been clearly shown that this specific poison from the discharges of persons sick with typhoid-fever, when kept away from exposure to the air, maintains its potency to produce the parent disease for some time, and that it may be conveyed long distances in water or milk. How far it multiplies and under what circumstances, outside of the human body, of course we have no means yet of positively stating. It is destructible readily upon free exposure to pure air, as was markedly shown, for instance, in the recent great epi-

demic at Croydon, England. Fourteen hundred cases occurred in that city, distributed chiefly by sewer-gas, and a great portion of the dejections from them passed into the sewers without disinfection. The sewage from these sewers was spread over an irrigation-farm, to the emanations from which large numbers of laborers and tenants near by were exposed. The water of the surface-wells in that vicinity, really the purified sewer-contents, constituted the almost sole supply for drinking and other domestic purposes for many people; and in no case was the fever propagated in that vicinity.

The specific poison of typhoid-fever is readily destroyed by boiling and by exposure to certain concentrated gases, like sulphurous acid and other efficient disinfectants.

Admitting the existence of a specific poison which may be so entirely eliminated from its filthy surroundings as not to lead to even a suspicion of its filth origin in the human intestine and its discharge with human excrement, the question remains, Is filth alone ever, under any circumstances or by any modifications, capable of producing typhoid-fever independently of any matter derived from a previous case of the disease? At the start we must acknowledge that in discussing this problem there is an *x*, an unknown factor, of which we know as little as we know of the so-called "germ" of any disease, — that is, we do not even yet know certainly that it exists. If we ignore this unknown factor, it must be admitted that the negative evidence enormously preponderates over the positive facts which tend to show that filth, independently of a specific poison, produces typhoid-fever.

Since the investigations of the Board have been directed to this point, it has repeatedly been shown that immense amounts of urine and excrement — oxidized, incompletely oxidized, and as they come from the bladder and intestines — are consumed in drinking water and inhaled at the rate of nine thousand litres of contaminated air a day, and this for years, by young, old, and middle-aged persons, without any disease resulting that may be attributed to filth. The danger of filth is not denied. Especially filth decomposing without the free access of air constitutes one of the most important secondary factors of disease, — one, too, which may become so essential a factor in some diseases as to absolutely be the one without which, in an aggravated form, the

disease cannot exist, as for example, in cholera, plague, and yellow-fever; but a risk, however great, should not be declared a certainty, nor should the influence of filth in causing disease be overstated, although not seldom an isolated filth-sodden well or cesspool, without any traceable connection with a previous case of typhoid-fever, *seems* to be the essential cause of that disease in persons exposed to their influence.

Where typhoid-fever seems to originate in filth, the filth is often, at least, so lost sight of that it can be recognized only by an expert. It is found in the typical New England village, where people take especial pains to keep their houses clean, to empty their privy-vaults twice a year, to put their wells at what is commonly thought to be a safe distance from sources of pollution. The well-water, on chemical examination, shows a trace simply of impurity, or only justifies the assertion that there is a suspicion of its pollution; the emanations from the soil, if dangerous, are not attended with any warning stinks, but there is a certain contamination of the earth with excrement, and a very possible admixture of a trifling amount of fæcal matter in the well. One case of typhoid-fever appears without a previous case having been known before in the vicinity; then another a quarter of a mile distant; then another; and then, as in the case of Saugus, reported in the ninth Report of the State Board of Health, seventeen cases appear in a population of one thousand people. The cases are widely separated, they are all mild, none prove fatal, and there is rarely more than one in a single house. There does not appear a chance for a specific community of cause, after the strictest investigation, for the single cases, or for the small groups of cases occasionally appearing together. They are scattered both over a large territory and over a considerable space of time, mostly in August and September, and they very seldom cause death, except when a patient thought pretty comfortable suddenly dies of intestinal hemorrhage.

Attended with this mild fever, there are cases where the temperature remains high for only a few days, and the illness lasts hardly over a week. In moderately malarious regions, it is not infrequently true that it is extremely difficult to make a correct diagnosis of the more obscure and protracted

of them, and to say definitely whether the illness is typhoid-fever or malarial-fever or one modified by the other. Very many such are observed, especially in the river-valleys and near natural or artificial ponds, notably where large areas of their exposed beds serve to exhale into the atmosphere the products of vegetable decomposition.

There seems to be abundant evidence from our country towns that filth under peculiar and unknown modifications, or *plus an unknown factor*, is sufficient, without the so-called specific germ *from a previous case*, to cause typhoid. The appearance, with the typhoid, of many mild attacks of fever of short duration suggests the suspicion that all are cases of filth-poisoning, of greater or less degrees of intensity, or that the filth in the various individuals has more or less of the unknown modification necessary to produce enteric fever, or that it is met by a greater or less predisposition to the disease. It is not impossible that future investigations may prove the existence of the communicability of typhoid-fever in this whole class of cases, where with our present knowledge such a demonstration is out of the question.

An important factor in the causation of the fever is often overlooked; namely, the predisposition of certain individuals or classes, the most potent causes of which are the underfeeding, want of cleanness, lack of pure air, water, &c., incident to poverty. Of 1,087 cases of typhoid-fever recently investigated in Berlin, the results of which were published by Dr. Skrzeczka, the ratio of the sick per 1,000 inhabitants increased from 0.83 in the basement to .84 on the ground floor, .96 and .95 in the first and second stories, 1.1 in the third story, and 1.4 in the fourth and fifth stories. In a recent number of the *Berliner städtisches Jahrbuch* similar statistics are given for the 939 deaths from typhoid-fever reported in the year 1875, excluding those where the story of the house was not stated in the death-returns; the figures are as follows: 0.89, 0.91, 0.95, 0.90, 1.03, 1.74. These calculations, in both cases, were based on the census of 1871; and the last figure given, 1.74, as the rate per 1,000 on the fourth and higher stories, is probably a little too high. All of course had the same water-supply. Those living at the top of the building had to carry the water for domestic purposes the farthest, and had the least facilities for cleanliness.

They were, too, the poorest, because the highest rooms were the cheapest. The remaining probable causes of the fever were certainly no worse for them than for the others; and on the more prevalent German theory, that the ground is the chief source of the cause of typhoid-fever, they were the best off, and yet they had the greatest percentage of enteric fever.

A telluric influence, something in the chemico-physical history of the earth, which we do not yet understand, apparently governs the relative prevalence of this, as well as other diseases, in different years and at different periods of time. In the minds of many careful observers, this constitutes the chief factor, with perhaps decay of organic matter.

Typhoid-fever is diminished by the introduction of pure water-supplies, and the cases which still occur where pure water is introduced have a lower rate of mortality than previously. Efficient sewerage, with perfect house drainage and pure water-supplies, has so favorable an influence on its prevalence as to practically banish the disease; and in cities in first-rate sanitary condition typhoid-fever becomes a disease of the apparently cleaner, but less well-drained, outlying districts. Defective sewerage, on the contrary, so tends to favor the spread of typhoid that we may always predict a progressive relative increase in its prevalence up to a certain point from the time that the sewers first become foul until they are made clean and self-flushing. This fact is so fully recognized in some European cities, that the local sewers are provided with means for flushing, and are flushed with clean water whenever there is an undue amount of typhoid. Enteric fever does not depend upon density of population, but it is prone to attack persons of deficient health from any cause, and the ill-fed. Our investigations tend to show that it is essentially a filth disease, in that its origin is always in decomposing organic matter, generally in what is filthiest of filth, human excrement.

It does not prevail most, however, in the filthiest towns, nor in the filthiest parts of towns, nor in the most stinking localities, nor necessarily in those years when stinks are most abundant or filth most accumulated; and in the sense of being an index of the degrees of filthiness of places, except where all the other conditions are exactly alike, unknown

factor and all, it is very far from being a typical filth disease.

Commonly speaking, enteric fever prevails more widely, other factors being equal, where excrement, decomposing without free access of air, contaminates water-supplies or the air of dwellings or near them; and, as those conditions obtain more in the country than in the cities, it is in the rural districts that it is most prevalent, but that law is by no means a constant one. So far as Massachusetts is concerned, impure water is one of the most common sources of infection; and in sewered parts of our cities sewer-gas appears to be its almost only local cause, for the water-supplies are usually excellent, and there are few vaults or cesspools. Using the census of 1875 as the base for comparison, — not an accurate method for absolute rates, but sufficient for our purpose, — it seems that for the ten years ending in 1878, typhoid-fever had a decennial rate per 1,000 in Hampden, the lowest of the Connecticut Valley counties, of 11.58; in Dukes and Nantucket, of 11.14; while the other two Connecticut Valley counties of Franklin and Hampshire come next as 10.41 and 10.24; then Berkshire and Barnstable, the extreme western portions and the Cape, 8.80 and 8.21; Worcester, or the central part, 7.52; Bristol and Plymouth, situated next to the Cape, 6.59 and 6.53; Essex, 6.23; Middlesex, 5.79, has one-half the extreme rate of Hampden, the greatest; Suffolk, 5.62; and finally Norfolk, 5.48.

There has been a steady decline in the disease during the ten years for the State at large, except that in 1872 and 1873 there was an increased prevalence. Suffolk County, however, does not show so great a decrease as the rest of the State; the total deaths in Massachusetts from that cause in 1869 being 1,205, and 679 in 1878. If Suffolk County (Boston, Chelsea, Revere, and Winthrop) be compared with the rest of the State, it appears, therefore, that its typhoid-fever record is an unfavorable one.

EXPENSES OF THE HEALTH DEPARTMENT.

JULY 1, TO DEC. 31, 1879.

State Printers, for Printing and Stationery	$544 54
Chemical Examinations, Professor Wood and Professor Nichols,	368 36
Postage	174 40
Travelling Expenses	123 32
Drawings	85 00
Messenger	64 70
Horse and Hack Hire	30 00
Stationery	29 47
Express (and Packing $.60)	23 00
Examinations for Trichinæ	19 35
Books and Reports	17 10
Sheriff's Notices	16 00
Copying	16 00
Examination, Brookline Water	12 00
Milk Investigations	10 00
Telegrams	6 12
Stenographic Reporter	6 00
Special Investigations and Reports (Drs. Abbott, Amory and Sabine, F. S. Billings, E. W. Bowditch, Dr. Brown, E. C. Clarke, Professor Farlow, A. Fteley, E. R. Hamilton, Dr. Mosher, Professor Nichols, Dr. Nickerson)	1,240 59
Salary of Secretary	1,250 00
Salary of Clerk	400 00
	$4,435 95

The Metric System.

LENGTH.

1 Myriameter	Mm.	(10,000 m.)	= 6.2137 miles.	
1 Kilometer	Km.	(1,000 m.)	= 0.62137 mile.	
1 Hectometer	Hm.	(100 m.)	= 328.0833 feet.	
1 Decameter	Dm.	(10 m.)	= 393.7 inches.	
1 Meter	m.	(1 m.)	= 39.37 inches.	
1 Decimeter	dm.	(0.1 m.)	= 3.937 inches.	
1 Centimeter	cm.	(0.01 m.)	= 0.3937 inch.	
1 Millimeter	mm.	(0.001 m.)	= 0.03937 inch.	
SURFACE.				
1 Hectare	Ha.	(10,000 sq. m.)	= 2.471 acres.	
1 Are	a.	(100 sq. m.)	= 119.6 square yards.	
1 Centare	ca.	(1 sq. m.)	= 1.550 square inches.	
CAPACITY.				
1 Kiloliter or Stère	Kl. or st.	(1.000 l.)	= 1.308 cubic yards	= 264.17 gallons.
1 Hectoliter	Hl.	(100 l.)	= 2 bushs. and 3.35 pecks	= 26.417 "
1 Decaliter	Dl.	(10 l.)	= 9.08 quarts	= 2.6417 "
1 Liter	l.	(1 l.)	= 0.908 quart	= 1.0567 qts. (1.761 imperial pints.
1 Deciliter	dl.	(0.1 l.)	= 6.1022 cubic inches	= 0.845 gill.
1 Centiliter	cl.	(0.01 l.)	= 0.61022 cubic inch	= 0.338 fluid ounce.
1 Millimeter	ml.	(0.001 l.)	= 0.061 cubic inch.	= 0.27 fluid drachm.
WEIGHT.				
1 Millier or Tonneau,	M. or T.	(1.000 Kg.)	= 1 Kl. or 1 Cu. m.	= 2204.6 lbs. (avoirdupois.)
1 Quintal	Q.	(100 Kg.)	= 1 Hl. or 0.1 Cu. m.	= 220.46 pounds.
1 Myriagram	Mg.	(10 Kg.)	= 1 Dl. or 10 Cu. dm.	= 22.046 "
1 Kilogram	Kg.	(1.000 g.)	= 1 l. or 1 Cu. dm.	= 2.2046 "
1 Hectogram	Hg.	(100 g.)	= 1 dl. or 0.1 Cu. dm.	= 3.5274 ounces.
1 Decagram	Dg.	(10 g.)	= 1 cl. or 10 Cu. cm.	= 0.3527 ounce.
1 Gram	g.	(1 g.)	= 1 ml. or 1 Cu. cm.	= 15.432 grains.
1 Decigram	dg.	(0.1 g.)	= 0.1 ml. or 0.1 Cu. cm.	= 1.5432 "
1 Centigram	cg.	(0.01 g.)	= 0.01 ml. or 10 Cu. mm.	= 0.1543 grain.
1 Milligram	mg.	(0.001 g.)	= 0.001 ml. or 1 Cu. mm.	= 0.0154 "

One kilogram is equal to a weight represented by one liter of distilled water at 4° C. In the centigrade scale 0 (32° + F.) is the freezing point; 100° + (212° + F.) is the boiling point. Five degrees C. corresponds to nine degrees F.

All measures in the metric system are derived from the meter, and their names express their values. Some of the names in the French system (like our "dime") are not in practical use; e.g., hectometer, decagram, &c.

One inch = 2.5 centimeters nearly; one quart (wine measure) = 0.946 liter; one pound troy = 0.373 kilogram; one acre = 0.4046 hectare.

THE POLLUTION OF STREAMS.

THE WESTFIELD AND MERRIMAC RIVERS.

By THE SECRETARY.

POLLUTION OF A BROOK BY SULPHURIC ACID.

By PROFESSOR NICHOLS.

THE WESTFIELD RIVER.

In continuation of the investigations begun by Mr. J. P. Kirkwood, C. E., under the direction of the Board, in 1875, the Westfield River basin, lying partly in Franklin, Berkshire, Hampshire, and Hampden Counties, has been examined during the year. The survey was made by Mr. E. R. Hamilton, C. E., the more important localities having been afterwards visited by the secretary of the Board. The chemical examinations were made at the laboratory of the Massachusetts Institute of Technology, by Professor W. Ripley Nichols.

General Description of the Westfield River Basin.

The Westfield River rises in the town of Savoy, in the north-eastern part of Berkshire County: its general direction is southerly and easterly. Savoy is a farming town, as are the neighboring towns of Windsor and Plainfield, which are drained by the Westfield River next below Savoy. About three miles south-east of Windsor is the village of West Cummington, at which place there is a paper-mill that gives employment to forty hands. There are also a wood-working shop, and a very small paper-mill which employs but three men, a mile and a half below. These are the only manufactures in Cummington, except saw-mills. The next towns drained by the Westfield River are Worthington and Chesterfield, both of which are very thinly-settled farming communities.

Twenty miles south of the village of Cummington, at the village of Huntington, and a little above it, the main river is joined by the West and Middle Branches.

The Middle Branch rises in the eastern part of the township of Peru, and flows in a southerly and easterly direction to its junction with the main river; it drains the easterly

parts of Peru and Middlefield, all of the town of Worthington, and the eastern part of the town of Chester. The entire section of country drained by the Middle Branch is a thinly-settled agricultural district, and has no manufactures.

The West Branch rises in Washington, and runs in a south-easterly direction to its junction with the main river at Huntington. It drains the eastern part of Washington and Becket, the southern part of Middlefield, all of Chester but the northern part, and the northern part of the town of Blandford. At North Becket there is a tannery and currying shop, employing thirty hands, and turning out three hundred hides per week. It is stated that the tannery is about closing up, and that the business is to be transferred to New York State, where bark can be bought cheaper. At Middlefield Station, on the Boston and Albany Railroad, three miles below Becket Station, there is a paper-mill employing seventeen hands, where they turn out about two tons of manilla paper per day. Another mill, not yet completed, about half a mile farther down the river, will be of nearly the same size as the last-named, and will manufacture wall-paper. This building is to replace one which was destroyed by fire July, 1879. North of Middlefield Station, two and a half miles up Factory Brook, there are two broadcloth-mills, which together employ seventy-five hands, and produce about five hundred yards of cloth per day. At Chester Village, a few rods up Walker Brook, four miles below Middlefield Station, there is a tannery which employs eleven hands, and turns out thirty hides per day. About a quarter of a mile above this tannery, on the same brook, there is an emery-mill. Between Chester and Huntington villages, on the north bank of the river, there are two emery-mills; but the only refuse from such works is stone and iron dust.

At Huntington, eight miles below Chester, there is a woollen-dress-goods mill, employing one hundred and twenty hands, running sixteen hundred and twenty spindles and seventy looms. The water below the mill is at times much discolored by the dye-stuffs, and in hot, dry weather gives off an unpleasant odor, but is not sufficiently offensive to cause general complaint. On the main river, half a mile above its junction with the West Branch, is a paper-mill

employing seventy hands. These are the only manufactures at Huntington.

Blandford, which lies south of Huntington and Chester, is a thinly-settled farming town; as is Montgomery, which lies just below Huntington on the north bank of the river.

A mile and a half below Huntington, in Russell, on the south bank of the river, is a paper-mill employing one hundred hands, manufacturing fine writing-paper. About five miles below this mill, on the same side of the river, and in the same town, is another paper-mill of the same capacity, and making the same kind of paper.

Five miles farther down the river is Westfield, which is the largest town in the Westfield basin, and the only one that has a full public supply of water. In West Springfield there is a partial supply. In all the other towns the inhabitants are supplied with spring-water from the neighboring hills and by wells. The source of supply for Westfield is among the hills in Montgomery, and is very pure spring water. There are plans for a system of sewers for Westfield, but no definite action has been taken towards building them as yet. At present the largest part of the direct drainage of the town is into Town Brook, which is a rapid stream running through the middle of the town, and emptying into the Westfield River about a mile below. Westfield lies on a plain, surrounded by high hills; but the soil is sandy, and easily absorbs all surface water. The principal business of the place is the manufacturing of whips and cigars, there being thirty whip-manufactories and about forty cigar-manufactories. The whip-factories are run by steam-power, and neither they nor the cigar-factories have any offensive refuse. Besides the whip and cigar factories, there are two machine-shops and a church-organ factory, also two paper-mills on the Little Westfield River.

Directly south of Westfield, lies the town of Southwick, the greater part of which is in the Westfield River basin. It is a thinly-settled farming community, and contains no manufactories. Below Westfield, the river drains the westerly part of the township of Holyoke, the westerly and extreme southerly part of the town of West Springfield, and the northern part of the town of Agawam, and finally empties into the Connecticut River opposite the city of Spring-

field. The portion of Holyoke that drains into the Westfield River is a quite hilly and very thinly-settled region, and contains no manufactories. The portion of West Springfield drained by the Westfield River contains two paper-mills and one cotton-mill. The land rises well up above the river, and is naturally well drained; the soil is sandy. It is not a thickly-settled community. The same is true of the land on the south side of the river, in the town of Agawam.

The whole country lying within the limits of the Westfield River basin is a thinly-settled, hilly region, abundantly supplied with the purest water, and naturally well drained. The soil is mostly of a sandy nature. The river and most of its branches have a steep fall along their entire length; and, the current being in consequence very swift, the small amount of impurities which are let into the river from the few and widely separated manufactories are very soon rendered imperceptible to sight, taste, or smell. The water throughout the country is apparently very pure. The whole region within the basin is very free from any nuisances caused by town-sewage or manufacturing-refuse, the only exceptions being in the discharge of spent tan-bark in North Becket from a tannery, and the refuse from the woollen-mills in Middlefield and Huntington, from both of which there is some complaint of occasional nuisance.

Area and Population.

The Westfield basin has an area of 529.58 square miles, calculating the line of the water-sheds as nearly as can be done by means of the maps now in existence, and without making a special survey for that purpose.

The population of the towns lying in considerable part within the basin was 26,501 in 1855, 26,416 in 1865, and 30,006 in 1875. Small portions of the population of Savoy, Windsor, Peru, Goshen, Washington, and Granville, — from one-eighth to one-fourth, — and not far from three-fourths of the population of Ashfield, Agawam, and West Springfield, lie outside of the drainage area of the Westfield River. The population within its water-shed has been estimated at 22,141 in 1865, and 24,365 in 1875, an increase of ten per cent in ten years, and being at the rate of 46 to the square mile.

Westfield is the only town having over 1,500 inhabitants

within the Westfield River basin, except possibly Chester, in which the new industry opened in the emery-mills has probably caused a moderate increase in the population since the last census; the greater parts of Agawam and West Springfield drain into the Connecticut River.

The twenty-two towns showed a slight decrease in their number of inhabitants between the censuses of 1855 and 1865. In the next ten years, there was an increase of fourteen per cent. During the twenty years, Chester increased eleven per cent, Westfield eighty-four per cent; the two towns draining chiefly into the Connecticut River, Agawam and West Springfield, increased respectively forty-six per cent and seventy-eight per cent. The remaining eighteen towns had smaller populations in 1875 than in 1855. The increase of population within the drainage area of the Westfield River and its tributaries between 1865 and 1875 was due to the prosperity of four towns overbalancing the emigration from the other eighteen.

The following table shows the distribution and movement of the population in the last twenty years: —

TABLE I. — *Population of Towns in Westfield Basin.*

Towns.	Population, 1855.	Population, 1865.	Population, 1875.
Savoy	919	866	730
Windsor	905	753	624
Plainfield	652	579	481
Ashfield	1,342	1,221	1,190
Peru	487	494	443
Cummington	1,004	980	916
Goshen	471	411	349
Worthington	1,112	925	818
Washington	1,068	859	603
Middlefield	677	727	603
Chesterfield	950	801	746
Becket	1,472	1,393	1,329
Chester	1,255	1,266	1,396
Huntington	1,172	1,163	1,095
Blandford	1,271	1,087	964
Russell	677	618	643
Montgomery	413	353	304
Granville	1,316	1,367	1,240
Southwick	1,130	1,155	1,114
Westfield	4,575	5,634	8,431
Agawam	1,543	1,664	2,248
West Springfield	2,090	2,100	3,739
Total	26,501	26,416	30,006

From the statistics above, it does not seem likely that any of the rural hill-towns will ever increase much more in population. Chester and Huntington have several manufactories and mills, but they are not likely to become large towns; Westfield is well situated for growth; while West Springfield and Agawam, lying directly opposite the flourishing city of Springfield, may reach considerable importance in size and prosperity.

WATER-SUPPLY AND SEWERAGE.

Pure water has been introduced in West Springfield and Westfield from storage-basins built by damming pure streams, — in the case of Westfield, from a mountain-brook in Montgomery. The supply is abundant, and free from danger of pollution. The other towns depend chiefly upon wells, — springs being occasionally used by individuals, and commonly with them lead-pipe.

There have been for several years propositions to introduce sewerage in Westfield; and with its abundant water-supply that may now be considered the chief sanitary need of the town. In the portion of West Springfield draining into the Connecticut River, about a square mile of territory has been protected by dikes from overflow of the rivers, and that part has been provided with sewers. The remaining towns depend chiefly upon vaults and cesspools.

The mills, as a rule, discharge all their refuse directly into the streams, including the contents of the water-closets, &c. This pollution of the water is seriously complained of, so far as could be learned, only at the paper-mill in Middlefield, where the spent tan from the tannery in Becket is sometimes a source of inconvenience. It can hardly be said that the excrement of a thousand operatives, and the refuse from mills so few in number, so small, and so widely separated, would affect the condition of the river differently, whether discharged directly into it or through town sewers.

POLLUTION OF THE RIVER.

At the present time, there is no noticeable pollution of the streams in the Westfield basin except from the tannery in Becket and from the mills in which scouring or dyeing is done; and, as a rule, even this is to be observed only for a

few hundred yards — or in some cases as many rods — while the vats are discharging. The spent dye-liquors, in Middlefield, are said to sometimes discolor the stream for a couple of miles, as is also the bark from the tannery in Becket. Commonly, nothing would be seen to markedly contaminate the river. The direct drainage of towns into it is inconsiderable. The towns, for the most part, have the neat appearance characteristic of New-England villages, their chief danger with regard to the subject of drainage being the pollution of wells by privies, &c. The river is rapid, and its volume is so great that no legislation is likely to be needed to preserve its purity, even if the sewers so much needed in Westfield should discharge directly into the stream. Indeed, twenty-five thousand people could be provided for without rendering the river offensive, and probably without injuring its water for use at the mills below, in West Springfield; even in the driest seasons, the least flow of the river recorded having been 35,547,431 gallons in twenty-four hours.

As suggested in previous reports of the State Board of Health, it is desirable to restrict the mills somewhat in their wholesale discharge of all sorts of refuse into the nearest river, especially when that can be done without any serious detriment to their interests.

Description and Location of the Mills.

In the mills for the finer kinds of paper, the rags are first thoroughly dusted by beating, the dust being carried off by means of a fan. The rags are then cut into small pieces about an inch or two square, sorted according to their quality, and then dusted again. They are then put into a rotary boiler, with one barrel of lime to two tons of rags, and boiled for twelve hours. The rags are then washed twelve hours in running water, ground more or less fine according to the length of fibre desired, put through the beaters and beaten until the pulp is of the requisite fineness, then run through the rollers which make it into sheets, and finally run through the sizing. Different quantities of alkali and different kinds are used in different places, according to the stock used and the amount of cleansing needed by it. In the manilla-paper mills, the process is essentially the same; coarser stock is used, however, and the pulp is not ground so fine nor bleached so white.

The process in tanneries is to soak the hides, and then scrape off the "fleshings," to drench them in lime to remove the hair, and then put them in a strong mixture of hen-manure and water, soaking them finally in the bark-liquor. The refuse consists of animal matter in suspension, hen-manure, lime, and ground tan-bark.

In the woollen-mills, the worst refuse comes from washing the wool with soap and alkalies. Some of the coarser coloring matters discolor the streams very much just after the emptying of the vats; but the tendency is more and more, each year, to use the more expensive and concentrated dyes, from which the waste is very small.

In the only cotton-mill in the basin, there is no bleaching or dyeing, and excrement from the closets is the chief refuse.

At the Crescent Paper Mills in Russell, the excrement is kept out of the stream and used as a fertilizer, as is the case also with the refuse from the paper-mill of Messrs. Crane Brothers in Westfield.

In the next table, are given the manufactures in the Westfield basin, exclusive of grist-mills, emery-mills, saw-mills, cigar-shops, whip-manufactories, and any others that do not pollute the streams. The amount of stock, &c., used is given as stated by the superintendents of the various mills.

TABLE II. — *Polluting Factories in the Westfield River Basin.*

NAME OF RIVER OR STREAM.	Description of Mill.	Location.	Head, and Fall in Feet.	No. of Hands employed.	Quantity of Materials used per Day.
Westfield River	Paper	W. Cummington	26	40	1,500 lbs. rags; 1 bbl. lime; 50 lbs. chloride of lime; 50 lbs. soda-ash; 100 lbs. animal sizing.
Westfield River	Paper	W. Cummington	20	3	600 lbs. sacking; $\frac{1}{2}$ bbl. lime; 200 lbs. chloride of lime.
West Branch	Tannery	North Becket	–	30	$\frac{1}{2}$ bbl. lime; $\frac{1}{2}$ bush. manure; $3\frac{1}{2}$ tons bark.
Factory Brook	Broadcloth	Middlefield	15	30	800 lbs. wool and shoddy; logwood, chrome, red tartar, vitriol, sumach, copperas, and blue vitriol.
Factory Brook	Broadcloth	Middlefield	–	45	
West Branch	Paper	Middlefield	27	17	3,000 lbs. stock; 30 lbs. chloride of lime; 1 bbl. lime; 20 lbs. soda-ash.
Walker Brook	Wall Paper	Middlefield	18	17	Nearly the same as the above.
Walker Brook	Tannery	Chester	17	11	2 tons bark; $\frac{1}{2}$ bush. hen-manure.
West Branch	Dress Goods	Huntington	10.5	120	400 lbs. wool; 80 lbs. silk; 170 lbs. cotton.
West Branch	Paper	Huntington	15	70	3,200 lbs. rags; 450 lbs. animal sizing; $1\frac{1}{2}$ bbl. lime; 200 lbs. chloride of lime; 80 lbs. alum.
Westfield River	Paper	Russell	22	100	3 tons rags; 330 lbs. lime; 33 lbs. chloride of lime; 80 lbs. soda-ash; 600 lbs. animal sizing; 160 lbs. alum.
Westfield River	Paper	Russell	22	100	Same as previous mill.
Little Westfield River	Paper	Westfield	20	75	2 tons rags; $\frac{1}{3}$ cask chloride of lime; $\frac{2}{3}$ bbl. lime; $\frac{1}{12}$ bbl. soda-ash.
Little Westfield River	Paper	Westfield	12	17	2 tons rope and sacking; 75 lbs. chloride of lime; $\frac{1}{2}$ bbl. lime.
Westfield River	Paper	West Springfield	27	70	3,000 lbs. rags; 150 lbs. lime; 25 lbs. chloride of lime; 25 lbs. alkalies; 500 lbs. animal sizing; a little rosin sizing.
Westfield River	Cotton	West Springfield	32	255	4,500 lbs. cotton.
Westfield River	Paper	West Springfield		90	3,500 lbs. stock; 300 lbs. chloride of lime; 140 lbs. lime; 140 lbs. animal sizing.
Westfield River	Paper	Agawam	8	40	$1\frac{1}{2}$ tons rags; 270 lbs. lime; 140 lbs. chloride of lime; 200 lbs. animal sizing.

The summary of these statistics appears in the following table.

TABLE III. — *Summary of Manufactures.*

	Number.	Operatives employed.
Paper-mills	12	639
Tanneries	2	41
Cloth-mills	2	75
Dress-goods.	1	120
Cotton-mill.	1	255
Total	18	1,130

The amount of water at the various points[1] was measured and calculated approximately by Mr. Hamilton, as shown in the following table, after a heavy rain. If only one-fourth of these quantities represents the dry-weather flow, there will still be much more than enough in the river-bed at all times to dispose of all the sewage that is likely to be discharged into it for at least very many years, if not for all time.

TABLE IV. — *Flow of Water at Various Points in the Westfield Basin in Twenty-four Hours.*

	A.	B.	C.	D.	E.
Cubic feet.	45,969,120	30,240,000	8,640,000	13,824,000	8,208,000
Gallons. .	343,872,921	226,210,925	64,631,693	103,410,708	61,400,108

The quite dry-weather flow at the point A is stated to be 84,919,581 gallons[2] in twenty-four hours; the least recorded is 35,547,431 gallons.

TABLE V. — *Summary of Statistics.*

Drainage-area in square miles	529.58
River-flow (dry weather) in 24 hours, cubic feet at A . .	11,352,096
River-flow (dry weather) in 24 hours, U. S. gallons . .	84,919,581
Number of factories	18
Number of factories per square mile	0.034
Number of operatives in the factories.	1,130
Population in 1865	22,141
Population in 1875	24,365
Population per square mile	46

[1] See the map. [2] W. Chapman, chairman of selectmen.

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[1] See the map.

Considering the great volume of the river, and its rapid flow, and also the small amount of impurity discharged into it from towns and mills, one is prepared to find very little evidence of contamination, as is shown in the following table, where the numbers 5 to 1 refer to points on the map. The water is very soft.

TABLE VI. — *Examination of Water from Westfield Basin.*

[Results expressed in parts in 100,000.]

Date of Analysis.	Locality on the Map.	Unfiltered Water.		Solid Residue.		Total at 212° F.	Chlorine.
		Ammonia.	"Albuminoid Ammonia."	Inorganic.	"Organic and Volatile."		
Nov. 15	5	0.004	0.015	1.64	2.44	4.08	0.10
Oct. 30	4	0.001	0.011	2.76	2.16	4.92	0.12
Oct. 30	4	0.002	0.009	3.04	1.74	4.78	0.16
Oct. 30	3	0.001	0.007	2.88	0.92	3.80	0.12
Oct. 30	3	0.001	0 005	2.53	1.47	4.00	0.11
Oct. 30	2	0.003	0.009	3.32	1.16	4.48	0.18
Oct. 30	2	0.003	0.008	3.34	1.46	4.80	0.19
Oct. 30	1	0.003	0.009	4.02	1.12	5.14	0.20
Oct. 30	1	0.004	0.011	3.90	1.22	5.12	0.17

The waters were quite clear, and not very much colored; the first five in order were rather more colored than the remaining four. No one of them gave any re-action for nitrates in the unconcentrated water by the ferrous sulphate test.

THE MERRIMAC RIVER.

A PRELIMINARY examination of the Merrimac River was made Sept. 25, 1879, the results of which it seems desirable to give this year, although it was not possible to carry the inquiry so far as it was the original intention to do, leaving fuller investigations for a subsequent report.

The water was taken for analysis at Lowell by the secretary, and in Lawrence by Mr. J. C. Hoadley, of the Board, when the river was somewhat fuller than in the ordinary dry-weather flow. The first two specimens were taken in Lowell, above Pawtucket Dam, and from the northerly and southerly sides respectively of the river, about one hundred feet from the banks, opposite the service-pipe for the direct supply of the city. No. 3 was from the Merrimac River, below all the sewers and outlets for the refuse of the mills, and just opposite its junction with the Concord River, from which No. 4 was taken. The reservoir (5) was supplied at that time from the filter-gallery (6), which is really a large, deep well near the bank of the river. No. 7 was taken seventy feet from the north shore, over the end of the direct supply-pipe. No. 8 a little higher up, two hundred feet from the shore. No. 9 was from the vicinity of the "snag," — a pile anchored with a heavy stone in the channel, and from the surface where the river is thirty feet deep. The last (No. 10) was from the main channel, one hundred and fifty feet from the shore of the island. The last four were collected in the late afternoon, ten hours after the first four, as that time represents about the interval between a certain body of water's leaving Lowell, and reaching Lawrence.

The quantity of water flowing in the Merrimac River at Lawrence, on the date of the examination, was, for the twelve hours from 6.30 A.M. to 6.30 P.M., nearly 4,600 cubic feet

per second; in the succeeding twelve hours, nearly 1,100 cubic feet; or at the average rate per second for the twenty-four hours of 2,850 cubic feet.[1]

The results of chemical examinations made by Professor Edward S. Wood, M.D., at the laboratory of the Harvard Medical School, are as follows: —

TABLE VII. — *Results of Examination of Merrimac-River Waters.*

[Figures express parts per 100,000 of water.]

Location.	Free Ammonia.	"Albuminoid" Ammonia.	Chlorine.	Residue.			Hardness.
				Fixed.	Volatile.	Total.	
1. Lowell — above the city	0.0040	0.0126	0.40	2.00	3.00	5.00	1°
2. Lowell — above the city	0.0054	0.0136	0.40	2.00	2.00	4.00	1°
3. Lowell — below the city	0.0021	0.0132	0.40	3.25	2.25	5.50	1°
4. Lowell — below the city	0.0021	0.0126	0.30	2.75	2.50	5.25	1°
5. Lawrence — Reservoir	0.0034	0.0164	0.40	5.60	3.70	9.30	1½°
6. Lawrence — Filter Gallery	0.0013	0.0100	0.45	5.25	3.75	9.00	1-1½°
7. Lawrence — River, near N. shore	0.0021	0.0140	0.40	5.50	3.00	8.50	1½°
8. Lawrence — River, opp. No. 5.	0.0021	0.0128	0.40	2.50	2.50	5.00	1-1½°
9. Lawrence — River, near "Snag"	0.0021	0.0126	0.50	7.00	3.50	10.50	1½°
10. Lawrence — River Channel	0.0008	0.0128	0.45	3.50	2.75	6.25	1°

If we compare No. 3, taken below all the sewers and mills of Lowell, with the average of 1 and 2, taken above the dam, we find a considerably less amount of ammonia, probably accounted for by the thorough aëration of the water in the fall over the dam; almost precisely the same amount of albuminoid ammonia; the same amount of chlorine; much more fixed residue (1.25), attributable[2] to street-washings, the immediate proximity of the mills, and surface-drainage generally; a little (0.25) less volatile residue; one part per hundred thousand more total residue, and the same hardness.

Averages from a considerable number of specimens would probably give somewhat different results from these just stated; but it is not likely that the present error is very great, and the samples were taken at 8.30 o'clock in the morning, when the discharge from the sewers was very considerable. A certain amount of oxidation might naturally take place while the water is passing over the high dam; but the sewer-outlets are below that point, so that there can be hardly any room at 3 for disappearance of the filth of the

[1] These measurements were kindly furnished by Mr. Hiram F. Mills, C. E.

[2] The samples were taken just after a moderate rain.

city by oxidation. A large part of the refuse from the mills might readily sink to the bed of the stream, being of greater weight than the water, taking with it some of the suspended organic matter; but the chief cause of the failure to clearly detect traces of a large city's refuse is in its enormous dilution, — the sewage of the city, twice as dilute as that of English cities, being mixed with six hundred times, or nearly a thousand times, its volume of water, in dry weather, according as the flow is calculated for twenty-four hours, or, as is more proper, for the twelve hours from 6.30 o'clock A.M. to 6.30 o'clock P.M.

In No. 4 is seen the influence of the admixture of the waters of the Concord River, into which is discharged a comparatively small portion of the Lowell filth, and which is less polluted in its general course before reaching the city, than the Merrimac River.

No. 5 is about the same as No. 6, as would naturally be the case, with an addition of a small amount of ammonia and albuminoid ammonia, due to its storage in a large open reservoir, exposed to the air, rain, and sun.

A couple of miles below Lowell, the water is considerably agitated by passing over Hunt's Falls, but, ten miles lower still, three out of four of the specimens (7–9) show the amount of ammonia unchanged: the albuminoid ammonia remains the same for the four; the chlorine is increased in only two; while the fixed residue, volatile residue, and total solids differ considerably, but perhaps no more than might be expected in a stream constantly receiving accessions to its volume from deep springs, &c., containing varying amounts of inorganic matter, which, not being thoroughly mixed with the general current, do not admit of accurate determination. At all events, it is found in practice that specimens of water, taken at the same time from adjoining places in a river, rarely agree entirely in their chemical constitution.

On all of the points which have just been stated, it is desirable to speak with a certain degree of reserve, until they can be confirmed by the examination of a large number of specimens. As they stand, so far as indicating sensible pollution of the river is concerned, they agree with the results published by the State Board of Health in their fifth report (p. 76), in a paper prepared by Professor William Ripley

Nichols, who made his chemical determinations from July, 1873, to January, 1874; those above Lawrence, however, having been made from the 9th to the 25th of September.

TABLE VIII. — *Results of Examination of Merrimac-River Water.*

[Results expressed in parts per 100,000.]

	Ammonia.	Albuminoid Ammonia.	Chlorine.	Residue.		
				Fixed.	Volatile.	Total.
Mean of 11 examinations above Lowell, 1873	0.0047	0.0114	0.14	2.37	1.73	4.10
Mean of 5 examinations above Lowell, September, 1873	0.0049	0.0124	0.13	1.76	1.88	3.64
Mean of 2 examinations above Lowell, September, 1879	0.0047	0.0131	0.40	2.00	2.50	4.50
Mean of 5 examinations below Lowell, July, 1873	0.0046	0.0098	0.16	3.39	1.52	4.91
1 examination below Lowell, September, 1879	0.0021	0.0132	0.40	3.25	2.25	5.50
Mean of 12 examinations above Lawrence, September, 1873	0.0044	0.0110	0.20	2.41	1.69	4.10
Mean of 4 examinations above Lawrence, September, 1879	0.0018	0.0131	0.44	4.62	2.94	7.56

It may be seen that the amounts of ammonia and albuminoid ammonia, at the different places and times, did not vary enough to warrant any positive deductions as to impurities, except that, in 1879, the amount of free ammonia below the dam diminished to one-half the amount found above it, as was not the case in 1873. For this curious fact no explanation is at present offered; indeed, it may have been accidental.

The amount of chlorine found in all the places was, in 1879, from two to three times as great as in 1873, although in no case excessive; while the relations between the amounts found in the three points in the river were very nearly the same, both years. The Merrimac River rises in a large, navigable, fresh-water lake, and flows through a farming region, not highly cultivated, beside receiving the drainage of the manufacturing cities of Concord, Manchester, and Nashua, and of its tributary the Nashua River. Under these circumstances, it would be natural for the amount of chlorine to vary from time to time; and it may be that those limits would include the variations just shown between the results of examinations in 1873 and 1879, — a point to be decided by making a large number of determinations at different times.

So far as the residue is concerned, it may be readily seen from Table VII. how wide a range must probably be allowed for natural differences in the character of the water, irrespective of any pollution by cities and mills. The four specimens taken at Lawrence exhibit the character of the stream in this respect. The results, however, so far as they go, seem to show to a slight extent the influence of the refuse from the city sewers, and perhaps the mills also, on the river at Lowell. In 1873, the means of the various analyses appear to show that, in flowing from Lowell to Lawrence, the water regained about the same degree of purity which it had above Lowell; while in 1879 that inference would not be fully supported. A different deduction, however, might be made if the averages were from a greater number of specimens, extending over considerable periods of time. Between the points examined just below Lowell and those above Lawrence there is no city-drainage or pollution from mills.

POLLUTION BY SULPHURIC ACID.

THE following account by Professor Nichols, of the accidental discharge into a brook of sulphuric acid, is an interesting illustration of the fact already stated, that seemingly great amounts of contamination may be easily lost sight of in large volumes of water.

On the night of June 2, 1879, a fire occurred in a chemical works situated on a brook whose waters eventually find their way into Mystic Pond, from which a portion of the city of Boston, Mass., obtains its supply of water. As a result of the destruction by fire of the sulphuric-acid chambers, a considerable quantity of sulphuric acid, estimated at fifty tons of oil of vitriol, together with salt cake and other chemicals, was washed directly into the brook, or flowed upon the adjoining meadow-land, from which it would slowly find its way to the stream. Large numbers of fish driven before the acid water, or actually killed by it, passed into the mill-ponds below and through the wheels of the mills. Anxiety was felt lest the acid should reach Mystic Pond itself; and, five days after the fire, specimens of the water were brought to Professor Nichols of the Institute of Technology for analysis. As far as Mystic Pond itself was concerned, the fears proved groundless ; but in the brook and in some of the upper ponds there was an abnormal amount of dissolved matter and especially of sulphates. The most interesting point, however, was with reference to the *acidity* of the water. As a rule, our surface waters in Massachusetts are naturally slightly alkaline, and, when the water is evaporated to dryness, the residue effervesces, at least slightly, when treated with acid.[1] It was found that even five days after the fire the water of the brook itself and of the nearest ponds was distinctly acid. The amount of acid was estimated by means of a dilute solution of baryta, using rosolic acid as an indicator.

The acidity was found to be as follows, the results being expressed by stating how many parts by weight of sulphuric acid (H_2SO_4), or its equivalent, were present in one hundred thousand parts by weight of the water; and also by stating, in round numbers, with how many parts of water, by weight, one part of sulphuric acid was diluted.

[1] Whether the alkalinity is to be regarded as due in part to the presence of alkaline carbonates, or as solely due to the presence of dissolved carbonate of calcium, is uncertain, as there are no analyses which are sufficiently particular to determine.

No.	Date.	Locality.	Acidity.	
			Parts of Acid in 100,000 of Water.	Parts of Water for one of Acid.
	1879.			
I.	June 7, A.M.	From brook just below works	1.74	57,500
IV.	June 7, A.M.	Lower end of Richardson's Pond, about 1½ miles below works	0.74	135,000
V.	June 7, A.M.	Frye & Thompson's Pond, about 3 miles below works	0.37	270,000
II.	June 7, P.M.	From brook midway between Chemical Works and Richardson's Pond, about ½ mile below works .	0.18	555,500
VI.	June 7, P.M.	From canal at Montvale, about 3½ miles below works	0.37	270,000
III.	June 8, P.M.	Upper end of Richardson's Pond	0.15	666,600

The localities may be fixed by reference to a map on p. 394 of the second annual report of the State Board of Health. I is marked 2 on the map, and represents a point just below the chemical works in a brook about three feet wide and two feet or so deep. II is about one-half a mile below I on the brook. III is about one-half a mile below II, and at the entrance of Richardson's Pond, which is a half-mile long and about twenty rods wide. IV is at the lower end of Richardson's Pond. V is about three miles below the works, at Frye and Thompson's Pond. VI is from Montvale Canal, which takes the bulk of the water from the brook at a point above the pond, the two re-uniting again below, and is about three miles and a half below the chemical works. Mystic Pond is between four and five miles below V and VI.

From the point numbered VI, that is, from the canal at Montvale, samples were taken at intervals until the water returned to its alkaline re-action. The results of the examination were as follows: —

Date.	Locality.	Total Solid Matter dried at 100° C.	Acidity in equivalent of H_2SO_4.	Total Sulphuric Acid free and combined, reckoned as SO_3	Remarks.
1879.					
June 6	Canal at Montvale Avenue, Montvale	11.6	0.22	4.7	The residue of evaporation did not effervesce with acid.
June 7		13.9	0.37	-	
June 9		12.8	0.26	-	
June 10		11.6	0.22	-	
June 13		9.4	0.16	-	
June 15		10.1	Slightly alkaline.	-	
June 19		9.4	0.16	1.2	Residue does not effervesce.
June 30		7.7	Slightly alkaline.	-	Residue does effervesce with acid.
July 8		8.4	Slightly alkaline.	-	

While the water was acid, the residue of evaporation did not effervesce with acid, showing that a part, at any rate, of the sulphuric acid was neutralized by the carbonates in the water. It may also be noted, that some fragments of marble were put into some of the water No. IV., which had an acidity of 0.74: after standing for fifteen hours, the acidity had decreased to 0.11, and after standing for two and a half days the re-action was neutral or faintly alkaline.

Samples were taken from the upper end of Mystic Pond for several days, but no acid re-action was at any time perceptible.

TRICHINÆ IN RELATION TO THE PUBLIC HEALTH.

BY

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TRICHINÆ IN RELATION TO THE PUBLIC HEALTH.

As a contribution to the subject of diseases of animals dangerous to the public health, the following paper is offered, embracing some original investigations on *trichinæ* in hogs slaughtered in Massachusetts. The inquiry has necessarily been limited, this year, to one branch of the subject, on account of want of time and opportunity to study the others.

The literature treating of *trichinosis* or *trichiniasis* is of comparatively modern origin; but we have no reason to doubt that the disease prevailed in swine at a very early date, and the consequential disease in man must have existed for years, if not for centuries, before it was recognized, perhaps dating back as far as the use of pork as food. The principal workers in this important field of investigation have been Owen, Cobbold, Bristow, and others in England; and Leuckart, Virchow, Gerlach, Haubner, Furstenberg, Zenker, and Kuchenmeister in Germany.

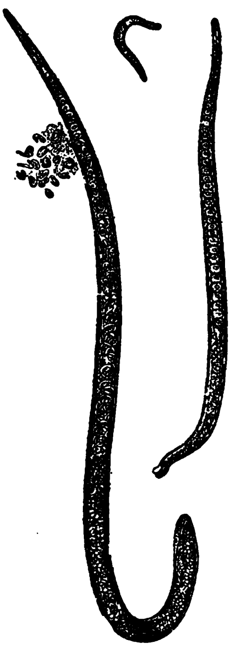

FIG. 1. Male Trichina, Female in process of giving birth to Embryos, and Embryo from Intestines. (Heller.)

"*Trichina spiralis* is an extremely minute nematoid helminth, the male in its fully developed and sexually matured condition measuring only one-eighteenth of an inch, while the perfectly developed female reaches a length of about one-eighth of an inch; body rounded and filiform, usually slightly bent on itself, rather thicker behind than in front, especially in the males; head narrow, finely pointed, unarmed, with a simple, central, minute oval aperture; posterior extremity of the male furnished with a bilobed caudal append-

age, . . . female stouter than the male, bluntly rounded posteriorly; . . . eggs measuring $\frac{1}{1270}$ of an inch from pole to pole; mode of reproduction viviparous."[1]

The illustrations in this paper are from Leuckart and Heller.

"The ova develop into minute embryos immediately on fructification, completely filling the uterus of the female, and are born in immense numbers. Scarcely have they become free from maternal protection, before they begin their migration over the invaded organism by penetrating the parietes of the intestines, in order to settle themselves in the muscles of the same, as muscle trichinæ: here, under the protection of a gradually calcifying, structureless capsule, the emigrated embryos, or muscle trichinæ, retain their vitality for years, while the sexually matured, or intestinal trichinæ, perish, as a rule, in the course of about five weeks. The embryos, which sometimes pass away from the intestines with the fæces, may, under favorable circumstances, also give occasion to the development of muscle trichinæ in a second animal, by gaining access to its intestinal tract."[2]

FIG. 2. Calcified encapsuled Trichinæ from the muscles of man. (Leuckart.)

As said above, these parasitic pests assume two forms, i.e., they may be met with as intestinal trichinæ and as muscle trichinæ, the first representing the sexually matured, the latter the embryonal (usually capsulated), stage of their existence. In order to offer even a very condensed sketch of the evolution which these parasites undergo, it is better to begin with the non-matured, or muscle form. The parasite, in this stage of development, limits its abode entirely to the striated or motory muscles. They have not been found in the non-striated or involuntary muscles, nor in the purely adipose tissue. The capsulated parasites may be met with in the

FIG. 3. Trichina Capsules, with contents and connective tissue. (Leuckart.)

[1] Cobbold, Entozoa, p. 335.

[2] Leuckart, Menschlichen Parasiten, vol. ii., p. 512.

striated muscles of all parts of the body; the heart seems, however, to be exempt, for they have been found in its tissues only in isolated cases (Leuckart, Fiedler).

In making examinations of the œsophageal muscles of a rabbit fed with trichinous pork, I was much struck with the abruptness with which one met with the trichinæ, in passing from the involuntary muscles of the stomach to those (voluntary) of the œsophagus; in fact, trichinæ could be seen where the fibres of the two interlaced, but in no case could I find a parasite in the non-striated fibres.

These parasites are not, however, equally distributed over the muscular system, but, on the contrary, seem to have their favorite places of abode. They appear to have a predilection for the muscles of the anterior part of the body. Among these, those of the tongue, larynx, pharynx, eye, and masticatory muscles are especially favored. The muscles of the body are more frequented than those of the extremities. Very few are found in the inferior portion of the tail of any animal. In the extremities, the parasites are found to be more abundant where the muscle-fibres begin to lose themselves in their tendinous extension, than in the body of the muscle. The following interesting and valuable statistics, with reference to the dispersion of the trichinæ over the organism, are taken from the "Mittheilungen aus der Thierärzlichen Praxis im preussischen Staate," 1877–78, p. 99. Department Veterinarian Johow, and Army Veterinarian Maximilian, having four trichinous swine at their disposal, have endeavored to establish the relative dispersion of the trichinæ in the different muscles of the body. To this end they prepared a great number of microscopic specimens from the different muscles of the body, which were on an average two centimetres long and one centimetre wide.

Eighty preparations from hog No. 1 gave the following results: —

a from the pillars of diaphragm . . .	12 trichinæ
b from the muscles of diaphragm . . .	4 trichinæ
c from the laryngeal muscles	1 trichina
d from the intercostals	no trichinæ
e from muscles of the tongue	no trichinæ
f from muscles of the neck	no trichinæ
g from muscles of the eyes and humerus .	no trichinæ

Sixty preparations from swine No. 2:—

a from pillars of diaphragm	10 trichinæ
b from muscles of diaphragm	6 trichinæ
c from laryngeal muscles	2 trichinæ
d from intercostals.	no trichinæ
e from tongue	no trichinæ
f from muscles of eyes, humerus, and neck .	no trichinæ

Forty preparations from swine No. 3:—

a from pillars of diaphragm	40 trichinæ
b from muscles of diaphragm	25 trichinæ
c from laryngeal muscles	4 trichinæ
d from intercostals	6 trichinæ
e from tongue.	8 trichinæ
f from muscles of neck, eye, and humerus .	2 trichinæ

Forty preparations from swine No. 4:—

a from pillars of diaphragm	40 trichinæ
b from muscles of diaphragm	30 trichinæ
c from muscles of larynx	10 trichinæ
d from intercostals	10 trichinæ
e from tongue.	6 trichinæ
f from muscles of humerus	2 trichinæ

Leuckart estimates that in some of the cases which have come to his observation, a single gram (fifteen grains) of flesh lodged from twelve hundred to fifteen hundred trichinæ. Assuming the muscles of a man to weigh forty pounds, the number of these parasites infesting a human organism, at such a ratio, would sum up some thirty millions. In Zenker's case, — to be noticed later, — Fiedler calculated that the woman lodged some ninety-four millions; and Cobbold assumes that a hundred millions may sometimes infest one organism at the same time. Leuckart says that no one would look upon the above as exaggerated estimates, who, like himself, has found some sixty trichinæ in ten millimetres of muscle. In a report of the Chicago Academy of Sciences, noticed in "The Boston Medical and Surgical Journal," vol. 75, it was estimated that one cubic inch of pork, examined under their auspices, contained some ten thousand, and that a person consuming the ordinary amount of such meat used at a single meal would introduce into his organism more than a million of these parasites. District Veterinarian Rauch[1]

[1] Preuss. Mittheilungen, l. c., p. 100.

(Wittenberg) found, in three hundred microscopic preparations of the flesh of an infected hog, that trichinæ were present in all but three. In some cases, there were thirty in one focus; in others, but five or six. In seventy specimens weighing one gram, three hundred and fifty trichinæ were found: at that rate one pound would contain a hundred and seventy-five thousand, and, if the flesh of a hog weighs a hundred pounds, it would, at such a percentage, contain seventeen million five hundred thousand trichinæ. In many cases, however, the parasites are much less frequently met with; and one has to search through many microscopic preparations before meeting any, and then only isolated examples.

When sufficient time has elapsed from the invasion of the muscles, and formation of the capsules, the latter become calcified, and may be recognized with the naked eye as small white specks, the infected muscles appearing as if sprinkled with grains of fine salt or white sand. The calcification of the capsule begins about the fifth month after the invasion of the muscles. In the ordinary pork which is generally offered for inspection, this is not the case, sufficient time not having elapsed for the calcifying process to take place, and the parasites, or, more correctly speaking, the capsules, are not to be seen with the naked eye, a magnifying power of fifteen to twenty diameters being sufficient to their recognition by the practised observer; but for exact inspection a power of fifty to seventy-five diameters is always to be preferred. The capsules do not always present the same form to the eye of the observer: sometimes they are well elongated; while at others they are more round, the usual extenuations at the ends being almost entirely wanting. Their average dimensions may be said to be 0.4 millimetre in length, and 0.26 millimetre in breadth. They not infrequently contain two, and sometimes three, parasites.

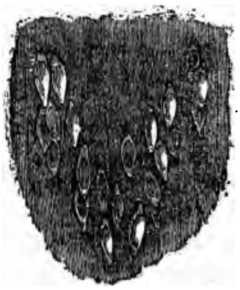

FIG. 4. Encapsuled and calcified muscle-trichinæ from man. (Heller.) × 10.

THE INTESTINAL TRICHINÆ.

So long as the trichinæ are in their capsules in the fibre of the muscle, their condition remains unchanged except to die or degenerate after the lapse of a long time; they make no progress in their development. They have been seen in an active condition, — i. e., capable of progressive development under suitable circumstances, yet encapsuled, — thirteen, twenty, twenty-four years, from the time at which their invasion had taken place. In 1861 a woman was admitted into the hospital at Altona, a suburb of Hamburg, Germany, suffering from a cancer of the breast which had been developing for some twelve years. On excision of the same, and subjecting portions of its tissue to microscopic examination, the presence of trichinæ was made manifest. On inquiry, it was ascertained that in 1856 the woman resided at Davenport, Ia., where she was taken suddenly very ill; gastric and rheumatic phenomena being the most manifest, together with œdema of various parts, and loss of power of motion of the limbs. Her brother, with whom she resided, was attacked in a similar but not in so severe a form, at the same time. The woman died at the hospital in question in 1864, and the examination of her flesh revealed the presence of great numbers of encapsuled trichinæ. A cat fed with pieces of the same died after the lapse of sixteen days, its flesh being completely filled with these parasites.[1]

Virchow relates a case, where, after the lapse of *thirteen and one-half years*, the parasites moved in their capsules on prolonged exposure to the heat of the sun.

Dr. Klopsch reports a case of trichiniasis, and complete recovery, which took place in 1842. The discovery of the parasites in this case was also made at the time of excision of a mammary tumor, which took place May 6, 1863, twenty-one years after the time of invasion. At the same time that the woman was ill (in 1842), two persons in the same house presented similar phenomena, and both died.[2]

Professor Damman, formerly of the Eldena Agricultural Academy, now at the Hanover Veterinary Institute, Ger-

[1] Boston Medical and Surgical Journal, 1866, vol. 74, p. 186.
[2] Archïv. für path. Anat. u. Physiologie, vol. xxxv., p. 609.

many, reports an interesting case of the longevity and encapsuling of trichinæ in the muscles of a pig. This hog was fed by Von Behr, in Schmaldow, with trichinous pork in November, 1864, and in February, 1865, was presented to the experiment station at Eldena. Since that time the animal had been kept isolated in a pen of its own, unless taken out for examination. A second feeding with trichinous meat had never taken place. On the 3d of February, 1875, and 20th of February, 1876, he removed a small piece of flesh from the muscles near the shoulder. In both cases the microscopic examination demonstrated the presence of trichinæ. Rupture of the capsule and the application of moderate heat demonstrated that they still lived. A considerable piece of flesh was removed, and fed to two rabbits; eighteen days subsequently their muscles were found plentifully invaded. In this case we have unquestionable proof of the presence and continuance of living trichinæ capable of development for a period of eleven and one-quarter years from the time of the infection of the swine.[1]

Although the capsulated trichinæ suffer no changes while confined in the muscles of a living organism, yet the introduction of portions of such muscles into the intestinal tract of man, or other suitable animal, causes rapid changes in their condition. The processes of digestion soon set the embryonal parasite free from its capsule, three to four hours being sufficient to the purpose; the freed parasites rapidly complete their development, becoming matured trichinæ. Thirty to forty hours are in general sufficient to complete this metamorphosis. In cases of fresh invasion, when the capsules have not become hardened to any great degree, twenty-four hours have been found sufficient to demonstrate the presence of sexually matured trichinæ in the intestines of animals fed with such flesh by way of experiment. Nevertheless one often finds parasites still enclosed in their capsules on the third day after feeding such flesh to an animal. There is scarcely another worm in which the matured stage is reached in so brief a period. Under these circumstances it must be evident that the changes necessary to maturity for these parasites are not very great.

As a rule, sexual connection takes place within two days

[1] Zeitschrift für Thierheilkunde, vol. iii., p. 92.

from the time the trichinæ become free. The parasites increase in length and thickness, and, in the female, the uterus fills with fructified ova, which soon develop into embryos enclosed in the body of the female. Leuckart states that the female intestinal, or matured, parasite lives from five to six weeks, and produces at least fifteen hundred embryos. In the intestines of the animal invaded, the females greatly predominate over the male parasites.

The newly-born embryos are at first buried in the mucus which lines the intestinal tract, as free and movable parasites. They soon, however, begin their migration and dispersion, the first act being the penetration of the intestinal walls. It seems still to be a matter of discussion, as to the means or ways by which further migration takes place. Some authorities, and among them the most eminent, as Leuckart, Furstenberg, and Gerlach, favor the view that the parasites proceed by way of the mesenterium and connective-tissue tracts over the system, and penetrate the sarcolemma, or connective-tissue membrane of the muscular fibres, to lodge in the substance of the same. Here the parasite develops a capsule or bed of finely granulous character for itself, the sarcous elements of the fibres of the muscles becoming wasted, or used up, and their striation lost so far as the capsule of the parasite extends. The sarcolemma of the muscle fibres forms a thickened secondary capsule around the parasite.

Another view, the possibility of which is conceded in a minor degree by the above-named authorities, is that the parasites gain access to the circulation, and are transported over the system by the moving fluid, boring through the smaller vessels at convenience, and by this means gaining access to the muscular tissues. An enthusiastic defender of this theory is Dr. Thudichum, an English observer. Were the blood the principal path of dispersion, we ought to be able to find numerous examples of the embryonal parasite in the circulating fluid of living animals which have been subjected to feeding-experiments. This has not been the case, however.

Thus it is evident that the consumer of trichinous flesh provides the means for its own infection. While this is in general the manner by which infection takes place, it by no means excludes the possibility of the infection of an animal

by intestinal trichinæ which have passed from an already infected organism with its fæces. In this way an infected swine may infect others, or in fact give occasion to a secondary infection of itself, by rooting in the manure of its pen. In the same way swine may become infected from infected men when, as is too often the case, the out-houses for the family are placed over the piggery, or lead into it, or where the contents of the same are thrown into the piggery for the swine to work over. Thus we see the cycle of infection may frequently continue from swine to man, and from man to swine.

Trichinæ have been discovered in Germany, England, Scotland, Denmark, France, Italy, North America, and South America, Africa, India, Australia, Spain, Egypt, and Syria. They have been found infecting man, cats, rats, dogs, mice, foxes, badgers, wild-hogs, and, according to the "Gazette Medicale," a young hippopotamus which died the 10th of May, 1879, at Marseilles, France.

Trichiniasis among Swine.

Although the recorded observation of the calcified trichinæ in the muscles of man may be said to date back to about 1821 (without any knowledge of their nature, however), and although the capsule was described by Hilton in 1831, and the parasite by Paget and Owen a few years later, still it was not until 1847 that Leidy described similar formations in the flesh of swine; the connection between those of man and swine being unquestionably established by Zenker of Dresden in 1860. Previous to this discovery of Zenker, these parasites were looked upon chiefly as curiosities exciting the interest of naturalists. Their direful nature was soon, however, established beyond all question by numerous epidemics to be hereafter mentioned.

It is to German investigators that we must look almost entirely for any authoritative statistics with reference to the numerical percentage of infection with these parasites, not only in the human family, but among swine; for in no other country is there at present any thing approaching a systematic examination of pork; and even in Germany there is much room for improvement, as there is in this entire field, viz., *the relation of animal diseases to human health*

Dr. Petri of Rostock gives the following statistics[1] with reference to the swine slaughtered in that city for a number of years: —

In 1869 the number of swine examined was 5,457, trichinous, 1; in 1871, 6,520, trichinous, 2; in 1872, 6,555, trichinous, 0; in 1873, 6,441, trichinous, 3; in 1874, 6,731, trichinous, 2; in 1875, 7,222, trichinous, 5; in 1876, 7,165, trichinous, 0; in 1877, 7,562, trichinous, 2. Total examined, 53,653; trichinous, 15: infected, 1 in 3,543.

In 1872, 622 American sides were examined, and 12 were found trichinous.

For Brunswick, Dr. C. W. F. Uhde gives the following interesting figures: —

From April, 1871, to 1872, number of swine examined, 93,707, trichinous, 7; from April, 1872, to 1873, 92,605, trichinous, 19; from April, 1873, to 1874, 102,580, trichinous, 20; from April, 1874, to 1875, 105,484, trichinous, 8. Total number of swine examined, 394,376; trichinous, 54: infected, 1 in 7,303.

In Prussia, from April, 1865, to 1866, 49 trichinous swine were reported. In Brunswick, from 1864 to 1865, 17,865 swine were examined, and only 1 infected. In Blankenberg, from 1864 to 1865, 7,000 to 8,000 swine examined, and only 1 infected. In Hanover, from 1865 to 1866, 18,656 swine were examined, and 12 found infected; for the years 1867 and 1868, 40 trichinous swine were reported for each year. In Sachsen-Weimar, from March, 1868, to 1869, 19,611 swine were examined, and but 1 found trichinous. In 1872 and 1873, numerous American sides and hams were found infected at Frankfort. At Liegnitz, 26 American hams were examined, and 2 found infected. In 1873 and 1874, at Magdeburg, between 7,000 and 8,000 swine were examined, and but 2 found infected. At Stettin, Erfurt, and other places, American pork came in for its share of condemnation. In 1875 and 1876, at Frankfort, of 8,000 swine examined, 4 were found infected; at Geslen, of 1,800, 1 was found infected. In 1876 and 1877, at one place 110 swine were examined, and 10 found infected. At Minden, 59 pieces of

[1] Virchow's Archiv. für path. Anatomie, etc.; Vierteljahrsschrift für gerichtliche Medicin; Deutsche Zeitschrift für Thiermedicin; Veterinary Reports of Saxony; Magazin für Thierheilkunde, and its successor, Archiv. für Thierheilkunde, and Mittheilungen aus der Praxis im preussischen Staate.

American pork were found diseased. In Schleswig-Holstein, from 1865 to 1874, 24,690 swine were examined, and 68 found infected, — 1 in 348.

The later Prussian reports indicate that the authoritative examination of pork is becoming better organized and more systematically executed, giving the following statistics of Dr. Eulenberg for 1876 to 1877, in all Prussia: —

Number of swine examined in 1876, 1,728,595; trichinous, 800; infected American pork, 220; number of inspectors, 11,915. In 1877, number of swine examined, 2,057,252; trichinous, 701; infected American pork, 243; number of inspectors, 12,865. Total number of swine examined, 3,785,-847; trichinous, 1,501. Ratio of infected, 1 in 2,522.

In 1875, at Charkow, Russia, 3,910 swine were examined, and 5 found infected. Of 210 pieces examined at Gothenburg, 8 were found infected.[1] At Elbing, two per cent of those examined were found trichinous. In Schleswig-Holstein, of 5,673 pieces examined, 47 were infected.

Examinations made in Germany in 1877 report 343 cases of infected American pork, and 183 cases of trichinosis among human beings. At Hamburg, in 1878, 297 American sides and 85 hams were found trichinous.

Statistics with reference to the percentage of infection with trichinæ among swine in England and France, as well as other Continental countries, are almost entirely wanting; at least, I have been unable to find any of value. German journals, however, are frequently enlivened with reports of the prevalence of these parasites in American pork.

Austria lays claim to a great immunity among her swine,[2] an explanation of which, it seems to me, must be sought in insufficient examination of slaughtered hogs. Professor Franz Mueller, of the Royal Veterinary Institute at Vienna, says that for years, neither in Vienna nor in its vicinity, has a single trichinous swine been found, notwithstanding investigation at the hands of experts, nor has a case of trichiniasis by man taken place.

On the 18th of February, 1879, a special meeting of the Royal and National Veterinary Association of Italy was held, to receive a communication from Signor Volanti, the muni-

1 Heller, Ziemssen's Handbuch d. Pathologie, iii., p. 411.

2 Oesterreich. Vierteljahrsschrift für Veterinärkunde, vol. 51, p. 176.

cipal veterinary surgeon of Turin. Volanti reported that trichinæ had been discovered in some American hams from Cincinnati, which had been sold at Turin, and that four per cent of the lot were infected. The association addressed a memoir to the Minister of the Interior with reference to a general measure towards organizing an efficient meat-inspection throughout the kingdom.[1]

The report of the Chicago Academy of Sciences gives, as the result of examinations instituted by them nine years ago among swine slaughtered at that place, that, of 1,394 examined, 28 were found infected. A recent examination,[2] instigated by Health-Commissioner De Wolf of Chicago, resulted in finding 8, of 100 swine examined, trichinous. A more detailed and laborious search among the medical journals of our own and other countries would doubtless greatly multiply these statistics.

The following interesting letter from the health-officer of Erie, Penn., shows how readily the disease may be overlooked without the careful scrutiny which he has exercised. Indeed, he says, in another note, that his finding trichinæ was for some time considered a hoax.

ERIE, PENN., Jan. 1, 1880.

DR. C. F. FOLSOM.

My dear Sir, — For six years I have examined, almost every day, pork, but could not tell the exact number of pigs examined. Since that time I am city physician and inspector of the market, &c. I had my office for eleven years just near the meat-market, which is held twice a week; and it was an amusement for me to look over a hundred farmers' teams, loaded with fresh meat. One day a butcher killed a very fine pig, in his estimate: he sold a fresh ham to a banker, who wanted me to look at it "just for fun." I put a small piece under the microscope, and found it full of trichinæ. It was a home-fed and corn-and-milk-fed pig. A German milkman killed four nice pigs, and had the meat examined: one of them was trichinous. A farmer D. sold two pigs to a Mr. K. He and the family of K. got very sick, and I found one of the pigs full of trichinæ. From a drove of Western pigs which were raised here I found several trichinous, and I think your estimate[3] is correct. I know only one case of death produced by trichinosis, — a young man nineteen years of age: others may have occurred under other names. Six years ago, at a German ball, smoked ham was served at midnight, and over a dozen people got very sick. Some blamed the beer and wine, but it was the

[1] Veterinary Journal, vol. ix., p. 286.
[2] Report of Chicago Board of Health, 1878.
[3] Somewhat less than the eight per cent observed in Chicago.

ham, full of trichinæ. In 1872 I observed two cases in Southern California: they were *rancheros*. In 1873 I found two families very sick in this city, and they recovered; also a tailor's family, who partook of the same meat. . . . From about twenty cases to my knowledge, all but one recovered, some only after a good deal of suffering.

Yours truly,
E. W. GERMER.

Dr. Germer adds, under date of Jan. 9, 1880, that he had recently examined a great many pigs without finding any trichinous. He reports a number of fatal cases in Warren, Penn., which occurred a few years ago, from frequently eating raw ham or sausages. One hundred and nine Western hogs were examined in Boston by Dr. Folsom, Dec. 24, 1879, with the result of finding none containing trichinæ.

At the request of the State Board of Health, Lunacy, and Charity, I have made an examination among swine slaughtered in the vicinity of Boston, extending over a period of five months. These examinations were not made upon any selected lots of swine, or upon those from any one place; but the pieces to be examined were collected at such days and times as I could find time and opportunity to examine them. The swine came from different parts of the country, mostly from the West, however. It is greatly to be regretted, that the exact place from which some of them came could not be ascertained, and exact examinations made as to their manner of feeding, surroundings, &c.; but such systematic work must await a future day, and abundant material support from the different State governments.

[illegible]

There is no doubt that the greater part of the swine which I examined were from the West; yet no one well acquainted with the circumstances would, I think, assert that the general hygienic conditions under which our Western swine are raised are not superior to those of the famed "home-fed porkers" of the small New-England farmer, raised, as they are in only too many instances, in dark, loathsome, poorly-ventilated pens, only too frequently under stables, with the house-vaults and sink-drains emptying into them.

Again, whoever has been upon a tour of observation among the agricultural districts of Germany must have been most forcibly struck with the absurd non-hygienic conditions under which not only hogs, but the majority of the domestic animals, are raised and surrounded, in comparison with those of our own country, especially of the great stock-raising West.

It is of the greatest importance to statistically establish, by means of a large number of exact examinations at the hands of competent and strictly honest observers, whether this great percentage of trichinæ-infected hogs is to be found among those fattened under the more unfavorable conditions offered by the large Western distilleries, in comparison with those offered by the open-air feeding, limited almost entirely to corn, of the Western farmer. The rigid inspection which has been begun, and is in the future to be still more rigidly executed; the numerous cases of infected American pork which are yearly being reported in Continental, especially German papers, and which are noticed in those of Great Britain; the too-numerous cases of disease among human beings traced to the same, — are gradually serving as an embargo, at least as a heavy import duty, which can but influence our foreign markets in this immense American agricultural product.[1] We have, then, as a nation, to discover why it is, that our Western swine, raised as they are under what appear to be more favorable hygienic conditions, are so much more infected with trichinæ than those of Germany, which are nearly all penned, and often given the contents of the out-house to root over.

[1] The census of 1870 gives the number of swine in the United States as 25,134,569.

It is well known that trichinæ have been found among the wild swine of Europe. It would be interesting to know the facts, in this regard, as to our own wild swine of the Southern and Western States, as well as the peccaries of Mexico and Central America.

The following[1] is given as an attempt at explaining the greater per cent of trichinæ among our swine: —

"The swine which are brought to the large slaughter-house are allowed to feed upon the refuse from slaughtered swine, and in this way have time and opportunity to infect themselves. Such infected swine are themselves slaughtered, and again infect those that may remain, or which may have arrived later. Accordingly this evil must go on constantly extending, and all persons must be earnestly warned against the consumption of raw American pork. By the so-called 'rapid smoking process,' practised in America, the trichinæ in the peripheral, or outside parts, of the hams, are doubtless killed, but those more deeply seated are not."

While the above assertion is absolutely false with reference to the large establishments, it is as strictly true, not only of many small ones where hogs are killed for home consumption, but also where they are kept, fattened, and killed by the farmer, or raiser, for the use of his family.

Dr. J. Meyer, sen., a very competent veterinarian at Cincinnati, writes under date of Oct. 16, 1879: —

"During the time that swine are quartered at the large regular packing-establishments, — which is generally from one to three days in the summer months, and one to six days in winter months, — they are fed upon corn and water exclusively. There are slaughter-houses, however, in which both cattle and swine are killed for the local trade, where the offal collected from the whole house is cast to the swine awaiting their doomed moment. This food is consumed in an uncooked state. The offal from the larger packing-houses is collected daily by the fertilizing-company, and transferred to their factory, where the fats are extracted by the aid of steam, the residue dried and made into fertilizing-material."

Dr. N. H. Paaren of Chicago writes under the same date: —

"No hogs are fed within many miles of the stockyards and packing or slaughtering establishments, except it be an occasional one kept by an Irish or German person and fed from the family kitchen. No part of the offal of the slaughtering-houses is used for feeding animals of any description."

[1] By Dr. O. Bollinger, professor in the Royal Veterinary Institute at Munich, in Deutsche Zeitschrift für Thiermedicin.

Dr. Bollinger's remarks continue as follows: —

"If we assume that one in ten thousand swine is infected, and from the refuse of the same two more become infected, the following geometric progression may take place: the first year, one swine trichinous; the second, two; the third, four; the fourth, eight; and so on, until in the course of fifteen years we have 16,384 swine infected from a single nucleus of infection. It is therefore right to warn the people against the consumption of American pork; and the microscopic examination of the same must in no case be neglected, as, in the American slaughter-houses, the breeding of trichinæ seems to be so regularly and thoroughly carried out, that no organized attempt could be hoped to equal it."

With reference to the disease itself among swine, I have taken the following from the "Magazin für die gesammte Thierheilkunde," xxxi. 6; being a report written by Professor Mueller of the Royal Veterinary Institute at Berlin, with reference to the results of a long-continued series of feeding-experiments with trichinous pork upon swine themselves. These experiments have demonstrated the fact that the consumption of trichinous flesh by swine, with the consequent development of the embryos in their intestines, and their migration and lodgement in the muscles, may indeed cause disease, but the symptoms of the same have neither that constancy nor character which will admit of their being considered as peculiar to this disease alone, during the life of swine so infected. All the swine which were fed with the trichinous flesh became ill within a few days after its consumption. The most constant phenomena presented were as follows: diarrhœa, not constant, but interrupted frequently by the passage of more solid fæces; appetite irregular, sometimes more, sometimes less, sometimes entirely wanting; indications of abdominal pains; turgidity of the lining membrane of the eyelids.

These symptoms, either singly or collectively, may appear in swine, or any other animal, entirely aside from any trichina-infection: most of them are simply evidence of the irritation caused by the parasites in the intestinal canal. Hence swine dying or killed at this stage of the invasion would present the same pathological phenomena as those suffering from an intestinal catarrh of like grade. As the migration of the embryonal trichinæ gradually ceases, so do these abdominal phenomena relax in their severity, and finally dis-

appear, unless a second invasion takes place. The invasion of the several muscular systems is indicated by pain, swelling, and disturbance of the motor functions. If these do not lead to death by exhaustion, they in their turn gradually cease with the encapsuling of the trichinæ.

The experiments of Professor Leisering, of the Royal Veterinary Institute at Dresden, entirely agree with the above. He says ("Bericht ueber das Veterinär-Wesen im Königreich Sachsen" 1862, p. 118), "One cannot speak of a trichina-disease in swine, which is characterized by distinct and pathognomonic phenomena. In this relation, the trichinæ deport themselves in a manner similar to the cysticerci (measles)." Leisering made some feeding-experiments with trichinous flesh by a horse, but the most exact examinations failed in discovering a single parasite in his flesh. It may also be casually remarked that fowls present some unknown hinderance to an invasion of their flesh by embryonal trichinæ. I made quite a number of experiments with hens, feeding them for two weeks almost entirely upon pork profusely infected, but was unable to find a single trichina in their flesh.

How do swine become infected under the natural order of things? or, in other words, whence do they derive the trichinæ? That the parasites gain access to an organism by means of the mouth and alimentary canal, is placed beyond all doubt. Notwithstanding the apparent negation of the above-quoted Berlin experiments, other authorities affirm, from positive observation, that intestinal and embryonal trichinæ do leave the invaded animal with the fæces, as is attested to by such observers as Leuckart, Vogel, Kuhn, Gerlach, and others. It is this form of migration, which under favorable circumstances also contributes to the distribution of the trichinæ. In fact, Haubner and Gerlach mention cases where they intentionally caused infection of young non-infected swine, by placing them with those known to be infected. Such embryos and pregnant females become mixed with the manure and bedding of the hog-pen, and may be taken up by any swine, even by those first invaded, thereby leading to a second infection, self-induced.

Is there no other factor in the question? We have previously remarked that wild swine have been found in-

fected with trichinæ, also cats, dogs, foxes, and other wild animals. Dr. Clendemin of Ostend examined a pike[1] caught in the North Sea, and found its flesh infested with trichinæ. He conjectured that the fish must have fed from trichinæ-infected refuse in the harbor of Ostend, and by this means have become infected. But, of all animals in which these parasites have been found, none have that interest to the hygienist and experimental pathologist which is enjoyed by the rat, on account of a hypothetical ætiological connection between the trichinæ which have been found to infest them in large numbers, and those of swine. Leisering is the originator of this hypothesis.

The following figures sufficiently prove that the rat lodges trichinæ in its flesh, even to a greater extent than any other animal which has as yet been subjected to examination. Of 704 rats from different parts of Germany, which have been subjected to examination, 59 were found trichinous, 8.3 per cent; of 208 rats from German Knackers, 46 found trichinous, 22.1 per cent; of 224 rats from slaughter-houses, 12 found trichinous, 5.4 per cent; of 272 rats from other places, 1 found trichinous, 0.4 per cent; of 326 rats from other places, 39 found trichinous, 12 per cent.

Of 51 rats caught at the Knacker establishment at Spectacle Island, Boston Harbor, 39 were found by myself to be trichinous, the tongues having been used for examination. The proprietors of this establishment kindly gave me an opportunity of examining 28 hogs which had been kept and fattened by them at the island in question. *None were found trichinous. These hogs received no city swill of any kind. What flesh they received had been subjected to the heat necessary to extract the fats; otherwise they received nothing but corn-meal.*

Forty rats caught at one of the large pork-packing houses near Boston were all found trichinous. Of 60 rats caught for me at different stables in the city of Boston, where no hogs were or had been kept, but six were found trichinous.

The results of these examinations are sufficient to strengthen my scepticism with regard to the rat-infection theory, and seem to indicate that the rats get the disease from eating pork, or from the swine, and not the swine from the rats.

[1] Archiv. für Thierheilkunde, Berlin, vol. v., p. 447.

I[illegible] question [illegible] trichinæ [illegible] that they have [illegible] that such a thing [illegible] hunger-ing [illegible] admitting that [illegible] trichinous [illegible]

[illegible] become in-[illegible] would not only [illegible] and carnivora [illegible]

[illegible] observations. [illegible] similar animals [illegible] the plants in [illegible]

[illegible]

[illegible] written upon this [illegible] that such [illegible] Almost [illegible] most profusely [illegible] diaphragm. [illegible] small stumps of [illegible] hog. When [illegible] in the [illegible] These pieces [illegible] without [illegible] was [illegible]

As [illegible] about a year [illegible] trichina [illegible] impossible [illegible] swine which [illegible] examined [illegible]

Although [illegible] is suffi-cient [illegible] observer, still [illegible] seventy-five [illegible] it be [illegible] American [illegible] dollars. [illegible] more suitable for such purposes [illegible] microscope

is of advantage for such examinations. Further, a few slides or object-glasses, some strong covering glasses, a pair of small curved scissors, and two teasing needles will complete the outfit.

The next step is, to take the piece of muscle to be examined, and, if at all dried, to make a fresh cut into its substance, then with the curved scissors cut one, two, or three thin slices lengthways to the fibres, i.e., with them, and with a needle place them upon the object-glass a little distance apart; the covering glass is then placed upon them, and gently pressed with a slight rolling motion in one direction and back if necessary. This will make the sections thin enough for examination. The free trichinæ, as shown in figure No. 5, are seldom found in swine, as they are not often examined after a fresh invasion.

FIG. 5. Fresh Trichinous Invasion. (Heller.)

To determine if the trichinæ still live, place the object-glass over heat, a spirit-lamp, a second, and then place again upon the microscope, and they will be frequently seen coiling themselves in their capsules. It is better, however, to finely tease out the preparation first, when individuals will frequently become freed from their capsules, and their movements can be better observed by the application of heat. Salted pork is best examined by taking the cuts from the scissors, and soaking them in fresh water for a second or so before placing upon the slide. They press out much easier and thinner, when such a procedure is resorted to.

Objects which may be mistaken for Trichinæ or not recognized as Such.

There are some possible sources of mistake in examining for trichinæ, as indicated below, but which can readily be

Fig. 6. Normal encapsuled Trichinæ. (Leuckart.)

Fig. 7. Pathologically changed Trichina-capsules. Trichinæ dead. (Leuckart.)

avoided with care. It not unfrequently happens that the capsules of the parasites formed by the sarcolemma, or embracing membrane of the muscle-fibres, become abnormally thickened, the trichinæ being dead within them. These capsules do not present exactly the same appearance as under normal circumstances, as may be seen by comparing Figs. 6 and 7.

In other cases the calcification is of such a character as to almost entirely change the appearance of the capsules and contents. (See Figs. 8 and 9.)

In some cases *cysticerci* (measles) perish and become calcified; but these formations are very much larger than those of trichinæ, and are often filled with a caseous mass. The "sacks of Rainey," or, as they are sometimes called, "psoro-

spermia," are elongated bodies, like the trichinæ, situated within the sarcolemma, the true nature and pathological

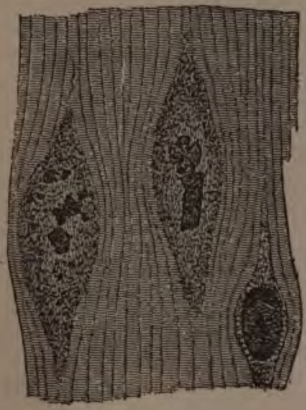

FIG. 8. Encapsuled concretions with dead Trichinæ. (Leuckart.)

FIG. 9. Trichina-capsules, with calcified and disintegrated capsules. (Leuckart.)

importance of which are not yet well determined. Some of the points distinguishing them from trichinæ are, that by the latter the striation of the muscle-fibre, or better the plasma, sarcous elements, is destroyed within that part of the sarcolemma which is included in the capsule of the trichina: by the psorosperms, however, it is retained, and only displaced by the object itself, limiting it on each side, and continuing directly from its poles. Bruch, Virchow, and Leuckart have described peculiar roundish or oval masses of a whitish color, of variable dimensions, which occasionally appear in the flesh of hams. The

FIG. 10. Psorosperms in muscle of swine. (Leuckart.)

same have been microscopically demonstrated to consist of agglomerates of needle-like crystals. They fill the muscle-fibres to a variable degree, without otherwise disturbing its structure, and disappear upon treatment with muriatic acid,

the normal transverse striation again becoming apparent. Figs. 10 and 11 will give an idea of these objects.

TRICHINÆ IN MAN.

It has been previously stated, that for some thirty years subsequent to the first description of the capsule by Hilton, and some twenty-five years after the identification of the parasite itself in man, the same were looked upon as mere harmless curiosities, and, that, although Leidy discovered the parasite in the flesh of swine in 1847, still it was not until 1860 that the connection was established between them, appearing, as they had, in two totally different species (men and swine). The honor of this important discovery belongs to Dr. Zenker of Dresden, Germany. The disease was discovered in a servant-girl admitted as a typhus patient to the City Hospital in Dresden. She died, and her flesh was found to be completely infested with trichinæ. At the same time that she became ill, other persons of the same family, and a butcher who had slaughtered a pig for them, were taken sick also; similar phenomena, but in a modified form, appearing in their case. An examination of the pork at the house revealed the presence of numerous trichinæ in its fleshy portions.

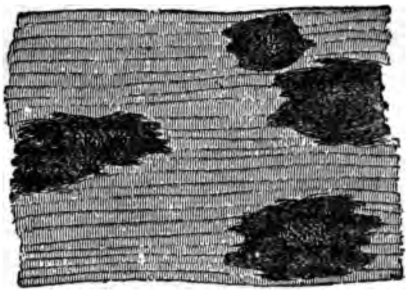

FIG. 11. Deposit of Tyrosin crystals in ham. (Leuckart.)

Dr. Thudichum (Seventh Report Med. Off. Privy Council, London, 1865) sums up the principal phenomena of trichiniasis in man as follows: "Sudden swelling of the face, particularly the eyelids, after the patient has for some days felt prostrate, and lost his appetite (this swelling causes a feeling of tension, but no pain); fever, with a quick pulse and copious perspirations, which not rarely have a repugnant odor; painfulness and immobility of arms and legs; the muscles are swelled and contracted, and give great pain when set in motion by the will or touched from without; in the worst

cases, the entire body is perfectly immovable and highly sensitive; there is gastro-intestinal catarrh (diarrhœa) with a red, somewhat covered tongue, inclining to dryness; when the swelling of the face has subsided, œdema of the feet, legs, and thighs comes on; shortly afterwards, anasarca, swelling over the trunk, makes its appearance."

From the time of the above-mentioned case of Zenker's, numerous others have been observed in different countries; and even epidemics of the disease have been reported, namely, at Corback 1860, Plauen 1861–2, Calbe 1862, Hettstadt 1862–3, Hanover 1864, Dessau 1864, and at numerous other places in Germany. The most remarkable outbreak was, however, at Hedersleben, a place of some two thousand inhabitants, of whom three hundred and thirty-seven were sick at one time, and one hundred and one died of trichiniasis.

Cobbold communicated to Heller, that the first authentic case of this disease, observed in man during life in England, was in 1871. Several most interesting examples of the discovery of the parasite in the muscles of living persons have been recorded in the annals of medicine. We have already alluded to the case of a woman suffering from cancer of the breast, trichinæ being found in portions of it on its removal (p. 30). The case of a stout and apparently healthy man entering a hospital at Calcutta with a tumor on his neck, and the subsequent discovery of trichinæ in the tissues of the same, is reported in "The Boston Medical and Surgical Journal," vol. 72, p. 167. Langenbeck of Berlin also removed a tumor in which the parasites were discovered. Professor Fitz of the Harvard Medical School lately reported to me a similar case, and remarked, that these parasites are probably more frequent in human beings in Massachusetts than is supposed.

Forty persons became diseased at one time at Bremen, from eating trichinous American pork. At Lissa five members of one family became infected from eating of a ham, which, it was said, had been pickled, then smoked, and boiled for two hours.[1] A poor woman became infected from the consumption of dog-meat, to which her necessities had driven her for nourishment.[2] At Linden, a suburb of Hanover, four

[1] Boston Med. & Surg. Jour., vol. 90, p. 491. [2] Ibid., vol. 91, p. 471.

hundred [illegible] and twenty-[illegible] [illegible]

[illegible] cases of this disease [illegible] New-York State, and [illegible] smoked [illegible] reported as [illegible] of the Medi[illegible] and 187[illegible], p. [illegible]

[illegible] cases of trichi[illegible] of the persons [illegible] the fresh [illegible] were found [illegible].

The [illegible] the fatal and [illegible] of the intes[illegible] the disease in man.

The following [illegible] Journal," [illegible] The Rochester [illegible] of trichinis[illegible] resulting [illegible] and [illegible] the woman [illegible] similar in [illegible] the dis[illegible] suffering from [illegible] the muscle removed [illegible] numerous [illegible] and Port H[illegible] of the Board of Health [illegible] Of the Port Huron cases, [illegible] died.

In Saxony [illegible] outbreaks of trichinosis have [illegible] of persons [illegible] these [illegible] small number of

Boston Medical and S[illegible]

[illegible] 2, 182

[illegible] Reichert Archiv [illegible] 187[illegible]

cases, the infection took place from eating raw pork; in most cases, however, *Knackwurst* and *Bratwurst* were the causes. The sausages are made from raw chopped meat, and smoked for one to two days, and eaten either cold or slightly fried. Of the 19 persons who died, 3 (of 8) were infected from raw meat, 2 (from 630 infected) from cold hacked sausage, 8 (from 340 diseased) from *Bratwurst* (fried sausage), and 2 (of 48) from ham: with reference to the other 4 there is no information. Of the 6,959,964 swine, which were slaughtered in Saxony during these 16 years, only 39, or 1 in 178,462, caused trichiniasis in man."

Table showing the Observed Cases of Human Trichiniasis in Bavaria.[1]

Number.	PLACE.	Year.	No. of Cases.	AUTHOR.	Where described.	Nature of Flesh eaten.
1	Würzburg .	1853,	2	Virchow .	Archiv., vol. 81, 1853,	Fresh raw meat.
2	Würzburg .	1861,	1	Kölliker .	Würz. Med. Zeit., vol. ii., p. 12, 1861 . .	
3	Erlangen .	1870,	8	Maurer .	D. Archiv. Klin. Med., vol. 8, p. 368 . .	
4	Erlangen .	-	1	Zenker. .	D. Archiv. Klin. Med., vol. 8, p. 388 . .	
5	Zweibrücken .	1870–71,	1	Friederick .	D. Archiv. Klin. Med., vol. 9, p. 459 . .	Swine from Baden.
6	Speyer . .	1873,	5	David . .	Communicated to Dr. Göring . . .	
7	Hof . . .	1878,	6	Roth . .	Ref. Aerztl. Kammer von Oberfranken .	Home-made pork.
8	Bamberg .	Feb. 1878,	30[2]	Roth . .	Ref. Aerztl. Kammer von Oberfranken .	Raw home-made ham.
9	Nürnberg	May, '78,	10	Merkel. .	Ref. Aerztl. Kammer von Oberfranken .	
10		June, '78,	3			Salted pork.
11	Freuchtbingen	June, '78,	4	Merkel. .	Ref. Aerztl. Kammer von Oberfranken .	Spiced pork.
12	Marktleuten .	July, '78,	19	Roth . .	Polizeiliche Zeitung .	
13	Burgsinn .	1879,	7[3]	Roth . .	Polizeiliche Zeitung .	

It is much to be regretted that the statistics of our medical schools and hospitals do not give us the exact number of cases where trichinæ have been found at autopsies of human beings. Dr. Bowditch reported three cases in "The Boston Medical and Surgical Journal" of 1842–44. Turner says of Scotland, that in five years one to two per cent of the human bodies were found trichinous. Fiedler found in Dresden 2 to 2.5 per cent to be in the same condition. Wagner in Leipzig reports one to every thirty or forty as infected. Virchow reports them as quite frequently met with. Zenker

[1] Bollinger, Zeitschrift für Thiermedicin, Bd. 5, Heft. 3 and 4, p. 204.

[2] One died. [3] Three died.

reports 1.79 per cent for autopsies seen at Dresden by him. Reports of like nature come from Italy, Russia, Sweden, and other countries.

Prevention.

1. The examination of slaughtered pigs by competent persons.

2. All pens and places for keeping hogs should be definitely regulated with reference to situation, contents, cleanliness, &c.

3. All sick hogs should be properly isolated from healthy ones, under the supervision of sanitary inspectors.

4. State boards of health should seek to educate the people in a knowledge of the subject.

5. As it has been demonstrated by my examination of the rats and hogs from the Knacker establishment at Spectacle Island, Boston Harbor, that while the former were nearly all trichinous, — thirty-nine out of fifty-one, — twenty-eight hogs were entirely free from trichinæ; as they receive neither city swill nor uncooked meat, it is indicated that these two questions can be very well studied at such places, and that, at very little cost to the State, valuable experiments can be made.

6. Boards of health should instigate exact researches into the hygienic conditions under which swine are reared; and no means should be spared in the endeavor to discover the real source from which swine obtain these parasites.

7. There should be continued examinations of rats in different parts of the country, at piggeries, and at places where no hogs are, or have been kept, until this rat theory of infection is absolutely settled.

8. No contents of water-closets, out-houses for human beings, or drainage from house-sinks, should be allowed to enter hog-pens, on penalty of the law.[1]

9. Feeding the offal from slaughtered swine to other swine, cooked or uncooked, or having slaughter-houses over places where swine are kept, should be forbidden by law.

10. Competently educated veterinary inspectors should be appointed by the State boards of health of each State, after

[1] Zenker reports a case where twenty-three swine were infected with trichinæ from consuming the drainage of a sink from a castle.

having passed a special examination in the principles of preventive medicine, to see that these various regulations, and others, with reference to other diseases, as well as contagio-infectious diseases strictly limited to animals, are strictly attended to.

Leuckart's and other experiments have shown that a temperature of 140° F. is necessary to securely render trichinæ inert. Direct heat applied to the slides holding specimens of trichinous pork, by means of the Schultz heating-table, has demonstrated, under the microscope, that a temperature of 50° C. (122° F.) is necessary to the certain death of the trichinæ.

Leisering's experiments with trichinous pork, made up into sausage-meat and cooked twenty minutes, gave positive results when fed to one rabbit, and negative by another. He sums up his experiments as follows: —

1. Trichinæ are killed by long-continued salting of infected meat, and also by subjecting the same for twenty-four hours to the action of smoke in a heated chamber.

2. They are not killed by means of *cold* smoking for a period of three days, and it also appears that twenty minutes cooking of freshly prepared sausage-meat is insufficient to kill them in all cases.

The various kinds of cooking, however, are quite different in their effects on trichinous pork. Frying and broiling are most efficient, roasting coming next. Boiling coagulates the albumen on the outer surface, and allows the heat to penetrate less readily; it should be kept up therefore for at least two hours for large pieces of meat. Whether boiled, broiled, or fried, pork should always be thoroughly cooked.

Practically speaking, the cooking, salting, and hot smoking which pork in its various forms receives in the United States must be in the vast majority of cases sufficient to kill the trichinæ, and prevent infection of the persons consuming the meat. Epidemics like those reported in Germany are unknown here, and trichiniasis in a fatal form is undoubtedly a rare disease. In the vicinity of the great pork-packing establishments near Boston, the "spare-ribs," containing the intercostal muscles, are very largely bought and eaten by the people near by; and trichiniasis among them has not in a

single case been reported, so far as I have been able to learn. The *cuts* being thin and well cooked, any trichinæ in them are quite certain to be killed. Even when trichinæ are introduced into the intestinal canal, too, they are sometimes expelled by diarrhœa, and the invasion of the system by a small number does no harm.

In this connection it seems not inappropriate for me to suggest that a most useful adjunct to the Health Department of Massachusetts would be an experiment station, situated within a convenient distance of Boston, probably in its suburbs, fitted up with a stable and suitable laboratories for pathological and chemical investigations. Such a station should not be a transient, but a permanent, attachment to the Board.

THE ADULTERATIONS OF SOME STAPLE GROCERIES.

BY

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THE ADULTERATIONS OF SOME STAPLE GROCERIES.

THE object of this paper is to show the general character of some of the staple groceries actually used in the State of Massachusetts; and the articles selected for this investigation were more especially those which have been suspected of adulteration with some mineral substances. For this purpose, flour, sugar, bread-soda, cream of tartar, and baking-powders were chosen.

In order to accomplish the object more effectually, the samples have been purchased, in every case, of the retail dealers in the several towns, without any suspicion on their part that the articles were to be tested. Endeavor was made to ascertain the manufacturer's name, if the article was sold in bulk. The more intelligent dealers readily gave the desired information. In many cases the clerk only was seen, and he did not know about the matter; in some cases the dealer himself professed not to know. In a few instances, the question seemed to arouse suspicion.

Nearly all the so-called "first-class" stores contain the best of articles. If they have a cheaper grade, they know its quality, and sell it only when something cheap is demanded.

Few persons are in a better position to know the ignorance and superstition of even seemingly intelligent people than a grocer in one of the larger inland towns. These ignorant and superstitious notions must be accepted, if the trade of the people is to be retained. One of the lasting prejudices is seen in the case of saleratus. As is well known, one finds in nearly all stores both "saleratus" and "soda," or "bread-soda." Some customers always purchase soda: some will not have it at any price, "Saleratus is so much stronger." Others say, "Soda is so much stronger," or, "It makes whiter bread."

The question, "What's in a name?" becomes all-important, not only to the dealer in groceries, but also to the manufacturer. One firm labels its packages "Pure bi-carbonate of soda. Free from all impurities contained in the best saleratus; twice the strength of pearlash saleratus." Another firm, on the same street, labels its packages "Paragon Saleratus. Contains from ten to twenty per cent more carbonic acid than can be found in any other saleratus." Another label says, "The country is flooded with wretched trash under the name of saleratus; and people have been so often deceived, that they have, to a certain extent, lost confidence in saleratus as a good healthy raising." The additional inducement to purchase this saleratus is found in the following statement, also on the label: "Will produce one-seventh more bread from flour, as nothing is lost by fermentation;" while a "Super-carbonate of soda" rivals the other with, "Saves ten per cent in every barrel of flour over old methods of yeast-fermentation; and a saving of nearly one-third can be made in the shortening." The fact is, that all these names are only selling-catches for one and the same thing, — more or less carefully refined and bi-carbonated "soda-ash;" the term "super-carbonate" being used by some shrewd firms to indicate the very highest possible degree of carbonization, which is interpreted by one very knowing Yankee dealer to mean "three times carbonated."

The "soda-ash," or carbonate of sodium, made from common salt by Leblanc's process, contains more or less sulphate of sodium remaining from the first treatment with sulphuric acid, and more or less chloride of sodium from the undecomposed salt. It still retains the commercial name of "soda-ash," which was given to it when carbonate of sodium was obtained only from the ashes of sea-plants. There is probably now on sale for bread-making none of the true pearl-ash saleratus, which is bi-carbonate of potassium, made from the ashes of land-plants. Pure bi-carbonate of sodium contains fifty-two per cent of carbonic acid. Equally pure bi-carbonate of potassium contains but forty-four per cent; owing to the greater equivalent weight of potassium, which is thirty-nine, while sodium is twenty-three. Consequently a given weight of bi-carbonate of sodium will furnish more carbonic acid than the same weight of bi-carbonate of potas-

sium, or saleratus, though both may be equally pure, and perfectly bi-carbonated; and, of course, the carbonic-acid gas is the part that is essential in raising the bread.

As has been stated, in nearly every town it is possible to obtain perfectly good articles; and it is by no means certain that only poor articles are kept in the stores of meaner appearance. Of the samples of cream of tartar obtained at especially cheap-looking stores, about one-half were as good as those purchased at the best places.

One fact seemed to be established in the course of this investigation: that the retail dealers, as a rule, sell what they buy, without change, and that whatever adulteration exists is to be found among the manufacturers and wholesale dealers. The object of the retail dealer is to buy, as cheaply as he can, any article that he can sell. If his customers will pay only eight cents a quarter for cream of tartar, he must buy so that he can sell for that sum.

The large centres of trade were visited, and information as to the districts supplied from each centre obtained. As one would suppose, Eastern Massachusetts is largely supplied from Boston and vicinity; while Central and Western Massachusetts are mainly supplied from New York and Albany, —from the latter centre chiefly. Some articles were found, purporting to come from Rhode Island and Connecticut. These were mainly in the southern central portion of the State.

When purchasing in a large town, care was taken to obtain samples from the very best and the very poorest, and also from a number of intermediate, stores. In the case of sugar, soda, and cream of tartar, it is believed that the report represents the actual quality used throughout the State.

As this report is limited in the main to the mineral adulterations, our examinations in the case of flour were confined to tests for a high per cent of ash, and for alum and lime in some form.

Twenty-five samples of flour from eleven towns have been tested: in no case has there been any evidence of mineral additions. In the poorer sections of the cities, baker's bread is almost exclusively used, so that the quality of such bread is of more importance in these quarters than the quality of the bread-making materials. Several small groceries were found, in which no soda or cream of tartar was for sale.

The reputed adulterations of sugar are glucose, chloride of tin, and chloride of calcium. Of sugar, seventy-five samples have been tested. From sixteen towns these were: —

Powdered	34
Fine granulated	26
Light brown	8
Dark brown	5
Cut loaf	2
Total	75

Not one of the sugars gave re-actions for tin. Of the white sugars, not one gave re-actions for chloride of calcium; one only out of fifty-five gave any indication of glucose, and that in a faint degree.

Of the thirteen brown sugars, seven gave slight re-actions for chloride of calcium. The worst two of these were analyzed, and gave respectively three-tenths and four-tenths of one per cent of chloride of calcium, and chloride of sodium, or salt, a quantity that might have been derived from the water used in the process of manufacture, and too little to do the least harm.

Of the thirteen brown sugars, six gave traces of reducible sugar or glucose, and three only gave considerable amounts, 8.3, 8.6, and 11.1 per cent respectively. Two of the three samples were of the darkest color found, and undoubtedly contained some molasses, which always carries a large per cent of reducible sugar, or glucose, formed in the process of the refining of the cane-juice. As honey is almost entirely composed of glucose, it is difficult to see wherein the "dangerous qualities" of the molasses glucose lie.

Of soda, the so-called "saleratus, bi-carbonate or super-carbonate, cooking-soda," — all being names for one and the same thing, — ninety-three [1] samples were obtained from thirty-five towns, twenty in packages, fifty-five in bulk, eighteen from known manufacturers. Of these, nineteen were nearly chemically pure, forty-three were good, making a total of sixty-two good. Twenty-five contained from three to sixteen per cent of chloride and sulphate of sodium; but, of these twenty-five, three only were very bad. The common

[1] Soda is largely sold in packages, hence the number of samples is smaller than in the case of cream of tartar.

salt, or chloride of sodium, and the sulphate, are simply left in from the crude soda-ash in the process of manufacture: they are not added to the carbonate for adulteration. We may dismiss the soda without fear. Nothing is cheap enough to be used for its adulteration; and the worst we have to dread is lack of purification of the crude soda-ash, which contains nothing injurious. The "wretched trash that floods the market" does not seem to be on sale in Massachusetts.

The results in the case of cream of tartar are not so favorable. As the best cream of tartar is liable to contain small quantities of tartrate of lime found in the imported argols, the samples containing less than three per cent of it are called perfectly good in the following table: —

Number of samples examined, from forty towns		160
perfectly good (fifty-eight per cent)	94	
containing more than three per cent and less than ten per cent of impurities	14	
consisting largely of terra-alba (sulphate of lime)	47	
almost wholly of terra-alba	9	
largely of acid phosphate of lime	12	
wholly of acid phosphate of lime	5	
largely of flour	1	
	182	
counted twice, as containing both acid phosphate, and sulphate	22	
	160	

Alum was not found in a single sample.

Of these samples, twenty-nine were put up in packages. Fourteen of these packages were marked with the maker's name and address, and warranted "strictly pure;" all of the fourteen, without exception, were good. Seven packages were found without the name of the manufacturer, only the name of the mills being given. Every one of these was adulterated; one was largely flour, the other six contained over fifty per cent of terra-alba. One other package had the maker's name, but no place of business on the label, and contained eighty-one per cent of terra alba. Two packages were labelled simply "Horsford's cream of tartar," and consisted of acid phosphate of lime.

Of twenty-four samples known to be of Boston make, only four were adulterated, and with less than fifteen per cent of

impurity. Of eight known to be of New-York make, four were good.

The price does not always indicate the quality. Some of the samples purchased for ten cents a quarter-pound were as good as others that cost fifteen cents. If one buys of the most trustworthy dealers, — the well-known and proved makers, — there will be comparatively little danger of adulteration. Not all people, however, are in a position to exercise such care in procuring the necessaries of life.

The following table will show some instructive results obtained in the course of the investigation: —

	No. of Towns.	Whole No. Samples.	No. containing less than 3 per cent impurity.	No. containing over 3 per cent impurity.	Terra-Alba.						Acid Phosphate of Lime.		
					Less than 10 per cent.	10 to 20 per cent.	20 to 50 per cent.	50 to 70 per cent.	70 to 90 per cent.	Over 90 per cent.	10 to 30 per cent.	30 to 50 per cent.	Over 60 per cent.
Cream of tartar from Eastern Massachusetts . .	26	110	73	37	3	9	9	7	2	-	9	5	2
Cream of tartar from Central and Western Massachusetts . .	14	50	21	29	3	1	8	9	3	4	5	1	3

The prevalence, in the central and western part of the State, of terra-alba or ground gypsum under the name of cream of tartar, is a very serious evil, and doubtless accounts for the great favor with which baking-powders are received in that section. One dealer in Pittsfield sells one pound of cream of tartar where he used to sell fifty, and his own was of the best quality.

Terra-alba may easily be detected by its insolubility in water. If a cupful of boiling water be poured on half a teaspoonful of good cream of tartar, it will dissolve almost instantly; whereas the quantity of terra-alba dissolved under the same circumstances is almost imperceptible. The acid phosphate of lime sold under the name of cream of tartar is about sixty per cent soluble in water; fourteen per cent of the insoluble portion is sulphate of lime left in the phosphate in the process of manufacture.

Neither the soluble nor the insoluble phosphate of lime

can be considered a harmful adulteration of bi-tartrate of potassium, ordinary cream of tartar. Terra-alba, although it cannot be classed among the poisons, is not exactly a wholesome ingredient of food. The worst feature of the use of terra-alba lies in the fact that it does not combine chemically with the soda, so as to neutralize the alkali. This was proved by direct experiment. Two pans of biscuit were made with equal quantities of flour and equal weights of pure bi-carbonate of sodium. To the one was added the usual amount of cream of tartar from a sample giving ninety-seven per cent terra-alba; the other was mixed with the soda alone, without any cream of tartar or substitute for it. Both were placed at the same time in the same oven, and when baked it was difficult to distinguish between them. Both were reasonably light, the heat of the oven being sufficient to set free the carbonic-acid gas. Both were of a fine golden yellow, and both were strongly alkaline.

Baking-powder, even though made with alum, is much to be preferred to such cream of tartar, for the alum does enter into chemical combination with the soda, and the alumina resulting from the change is as inert and harmless as so much clay; the sulphate of soda also formed is not excessively injurious.

Of baking-powders, thirty-three samples have been tested: eight of these were in bulk, twenty-five in packages, representing as many different makers.

Of the thirty-three samples, twenty-four were good; that is, they contained nothing injurious, the worst adulteration being an excess of flour or starch over that needed for the mixing of the cream of tartar and soda. The solutions in water were either neutral or slightly acid: hence in the use of these preparations there is no danger of an excess of soda. The twenty-four good samples were well-known and well-tried kinds. Of the remaining nine, eight contained alum, and five of the eight also contained ammonia.

Of the eight samples containing alum, three were in bulk, and five in packages. All but one were purchased in Western Massachusetts: that one was sold in bulk in a country town.

A large excess of starch was found in twelve samples, including the nine which were bad. In several cases the starch amounted to forty-five per cent.

Several samples of salt were tested, also several of vinegar. One of the latter showed chlorine, but the quantity proved to be only one-tenth of one per cent. No lead or other mineral matter was found, and no excess of sulphuric acid.

The question of the adulteration of sirup hardly came within the limits of this report, except as it relates to the presence of tin. Five samples were tested, and no tin or lead was found. There is a trace of iron, derived doubtless from the pans or kettles used in the process of refining. One suspected sirup was examined, which was evidently a manufactured article, but it was free from mineral matter. The ash was only .48 of one per cent.

My thanks are due to Miss Lucia M. Peabody for efficient aid given in the chemical examination of the various substances.

Localities from which Collections were made for Analysis.

	No. of Dealers.	No. Samples Cream of Tartar.	No. Samples Soda.	No. Samples Baking-Powder.	No. Samples Sugar.
Atlantic	1	1	1	–	1
Ayer	4	4	4	1	3
Boston	14	17	4	3	28
Brockton	2	3	3	2	–
Brookline	4	5	2	–	–
Cherry Valley	1	1	1	–	–
Concord	2	2	4	–	–
Danvers	1	1	1	–	–
Deerfield	1	1	2	–	–
Dunstable	1	1	1	–	1
Fall River	10	11	6	1	8
Fitchburg	9	9	–	–	2
Greenfield	2	2	4	2	6
Groton	1	1	1	–	1
Hanson	1	1	1	–	–
Holyoke	1	1	1	–	–
Lawrence	10	12	12	2	1
Leicester	1	1	1	1	–
Lowell	6	6	6	3	2
Lynn	15	17	–	–	–
Natick	1	1	2	–	–
New Bedford	5	5	4	–	8
Newton	1	1	1	–	–
Northampton	4	4	3	7	–
North Wilbraham	1	1	–	–	–
Palmer	1	1	1	1	–
Pepperell	1	1	1	–	1
Pittsfield	5	7	7	6	1
Saugus	1	3	–	–	–
Shrewsbury	1	1	1	–	–
Springfield	3	3	5	–	1
Sudbury	1	1	1	–	–
Taunton	2	2	2	–	2
Three Rivers	1	1	1	–	–
Turner's Falls	1	1	1	–	–
Waltham	2	2	4	2	4
Watertown	1	1	2	–	2
West Brookfield	1	1	1	–	–
West Warren	1	1	1	–	–
Worcester	20	25	–	2	3
Total	141	160	93	33	75

THE WATER-SUPPLY OF CAMBRIDGE.

BY

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CAMBRIDGE WATER-SUPPLY.[1]

It was supposed for a long time that Fresh Pond alone would be capable of supplying the citizens of Cambridge with water for an indefinite period; but experience showed that this was not the case, and that an additional supply was necessary to meet the increasing needs of the city. In the autumn of 1871 the level of Fresh Pond was only four or five inches above low-water mark, and in the winter of 1875 the pond was lowered so much that preparations were made to pump into the supply-pipe. The following record of the height of the pond, and the pumping-record, collected from the various reports of the Water Board, show the amount of the increase in the consumption of water, and the necessity for a source of supply other than Fresh Pond itself.

Average Number of Gallons pumped daily.

1865	962,127	1872	1,626,006
1866	1,111,339	1873	2,124,884
1867	1,244,180	1874	2,299,146
1868	1,732,759	1875	2,718,484
1869	1,613,050	1876	2,466,167
1870	1,739,869	1877	2,631,732
1871	1,747,704	1878	2,257,190

Height of Fresh Pond below High-Water Mark.

	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
December	44.	40.2	16.	36.62	69.	73.75	55.	26.50
January	44.6	37.	10.	21.62	78.	66.	54.	24.
February	41.4	40.	12.	24.37	88.62	65.50	50.50	20.
March	20.	38.	7.64	29.	79.12	61.37	24.	9.
April	20.4	26.	10.	27.25	67.	49.25	8.50	8.
May	21.	27.	17.	20.88	65.	44.37	11.87	9.
June	29.	22.	27.	23.50	50.37	48.75	21.	17.
July	38.5	27.	46.50	33.75	68.75	59.25	32.50	27.50
August	43.	18.	41.50	35.37	72.62	64.37	42.25	27.37
September	49.	9.	47.	45.38	76.37	68.62	51.75	31.50
October	48.	15.	50.	54.	72.	77.12	54.50	37.
November	45.	10.	43.50	59.62	69.50	61.37	47.	36.

[1] Republished, by permission, from the Report of the Special Committee on the Water-Supply of the City of Cambridge.

The Water Board also state in their report for 1876 (p. 15): "There was a general belief, in the early history of our water-works, that Fresh Pond would furnish an unlimited supply of water. The great droughts of 1872 and 1873 dispelled this illusion, when, for a considerable time, the amount we pumped out of the pond daily lowered the pond by just about the same amount of water as measured by its area."

Accordingly in 1875 the right was obtained to take water from Little and Spy Ponds and Wellington Brook as the sources for an additional supply; and these were connected with Fresh Pond by a conduit. I will first consider the impurities in Fresh Pond itself, and then in the sources of additional supply. The water of Spy Pond, having been found decidedly objectionable, has never been used, and will not, therefore, be considered in the following pages.

Sources of Pollution.

Fresh Pond. — The most important sources of contamination of Fresh Pond itself are situated upon the south-western side of the pond, in what is known as the Strawberry-hill or Cushing-street district.

Cider-mill Pond is the worst of these. It is connected with Fresh Pond below by an open ditch and a culvert under Cushing Street, whence it passes into a small bog, where it unites with the water coming from Richardson's Pond (next to be described), and with this flows directly into Fresh Pond: it is also connected with a small pond seven hundred feet above by a ditch, and another culvert under Cushing Street. Cider-mill Pond receives the drainage of quite a large number of privies, cesspools, and pigsties, some of which drain directly into the pond or ditch; and a large amount of human and animal excrement, together with kitchen-slops, are washed with every rain into it; it receives also the drainage from a cemetery. Inquiries which were kindly made for me by the city engineer show that "the area drained by the 'Cider-mill Pond' and the upper pond east of Cushing Street contains twenty-two dwelling-houses and six barns; there are twenty-nine families, consisting of eighty-nine adults and fifty-nine children. These families keep two horses, ten cows, and twenty-seven pigs. There are twenty-four privies, four of which overflow into the pond and connecting stream, and

many of the others are situated on a very steep slope leading to the ponds. A few of the houses may have covered cess-pools to receive the house-drainage; but in most cases it is discharged directly on to the ground, and a rain must certainly wash it into the ponds."

This pond receives the drainage of about fifty-three acres of territory, collecting and retaining, during dry seasons, all of the drainage and sewage; but after heavy rains it overflows, and discharges its accumulated filth through the ditch and culvert directly into Fresh Pond.

In March, 1878, a weir was constructed across the ditch, in order to determine how much of this highly polluted water gains entrance into Fresh Pond, with the following result: —

1878.	Gallons.	Rainfall in Inches.	1878.	Gallons.	Rainfall in Inches.
March 8 .	52,735	0.03	March 23 .	27,574	-
" 16 .	33,821	-	" 27 .	17,255	-
" 18 .	369,100	1.37	" 29 .	9,662	0.30
" 19 .	322,957	0.19	April 4 :	25,527	-
" 20 .	78,203	-	" 23 .	-	} 0.47
" 21 .	50,732	-	" 24 .	6,442	
" 22 .	27,574	-	" 26 .	6,442	0.62

These figures are interesting, as showing not only the amount of filth which may at times be discharged into Fresh Pond from this source, but also the influence of a heavy rain upon this pond; for on the 17th of March the outlet was nearly dry, when a rainfall of 1.37 inches on the 18th caused an overflow of more than three hundred and sixty-nine thousand gallons. The increase on April 4 was probably caused by melting snow, as there is no record of any rainfall.

The water in Cider-mill Pond is at all seasons very disgusting in appearance, and contains a large amount of organic matter both in suspension and in solution, as may be seen by the analyses in the table.

This sewage is, of course, diluted with an exceedingly large amount of water in Fresh Pond, which greatly diminishes the chance of its infecting the water in the pipes: yet such a chance must exist with more than two million gallons of water being drawn daily through the pumping-conduit; this

must create a certain amount of current toward the mouth of the conduit.

The population in this district is steadily increasing; and the contamination from this source is sure to increase rather than diminish, unless some means be taken to divert this sewage. Plans for such a diversion have already been presented by the city engineer.

Richardson's Pond is also a very important source of pollution of Fresh Pond. It receives the drainage from one hundred and twenty-two and one-half acres of territory, including a portion of the Hittinger estate, a part of which is highly manured and cultivated. The surface-drainage from this district is collected in gutters and brooks which flow through Mr. Hittinger's garden, where it is utilized for washing the vegetables, &c.; thence it flows through a long culvert into what is called Richardson's Pond, which is situated just above the schoolhouse at the junction of Cushing and Grove Streets. The discharge from this pond is through a culvert under Grove Street, through the schoolhouse yard and under Cushing Street, into the low ground below Cushing Street, where it unites with the outlet from Cider-mill Pond, and thence flows directly into Fresh Pond. Upon Mr. Hittinger's estate there is a piggery situated almost directly over the brook, before the latter enters the long culvert. In this piggery are kept three pigs for home use.

During dry seasons the outlet of Richardson's Pond is dry, but in wet seasons a very large amount of water is discharged directly into Fresh Pond. The amount of this surface-drainage, which is thus discharged, is shown by the following measurements, which were taken last spring at a weir constructed across the outlet just below Cushing Street, before the water unites with that coming from Cider-mill Pond: —

1879.	Gallons.	Rainfall in Inches.	1879.	Gallons.	Rainfall in Inches.
March 11	93,839	–	April 26	217,310	–
" 13	93,839	–	" 27	183,280	–
" 14	–	0.14	" 28	151,304	0.54
" 15	93,839	–	" 29	534,024	0.96
" 18	60,947	0.45	" 30	1,487,633	0.15
" 20	194,385	0 03	May 1	413,425	–
" 21	131,152	0.08	" 2	240,965	–
" 22	–	0.98	" 3	205,725	–
" 23	1,049,220		" 4	183,280	–
" 26	172,414	0.04	" 5	161,749	0.01
" 27	151,304	1.17	" 6	141,107	–
" 28	768,375	0.03	" 7	111,990	–
" 29	343,444	0.20	" 8	93,839	–
" 30	715,810	0 03	" 9	76,477	–
" 31	343,444	0.64	" 10	60,947	–
April 1	93,839	–	" 11	53,496	–
" 2	384,928	–	" 12	46,372	–
" 3	253,112	0.22	" 13	39,588	–
" 4	303,627	–	" 14	33,182	–
" 5	194,385	–	" 15	27,147	–
" 6	205,725	–	" 16	21,552	0.04
" 7	217,310	–	" 17	39,588	0.19
" 8	194,385	–	" 18	21,552	–
" 9	172,414	–	" 19	27,147	0.76
" 10	194,385	1.26	" 20	93,839	0.08
" 11	786,219	0.03	" 21	46,372	0.12
" 12	370,977	–	" 22	33,182	–
" 13	290,723	–	" 23	16,394	–
" 14	303,627	–	" 24	7,615	–
" 15	240,965	0.32	June 2	–	
" 16	370,977	0.03	" 3	–	1.35
" 17	265,457	0.72	" 4	53,496	
" 18	1,572,540	0.81	" 5	11,730	0.43
" 19	768,375	0.07	" 6	4,148	0.10
" 20	786,219	–	" 14	–	
" 21	502,920	–	" 15	–	1.12
" 22	384,928	–	" 16	–	
" 23	343,444	–	" 17	33,182	
" 24	265,457	–	" 18	dry.	–
" 25	228,963	0.02			

	Gallons.
Average of 13 days in March	324,155
" of 30 days in April	408,982
" of 24 days in May	91,532
" of 4 days in June	25,639

The rapidity with which a heavy rain influences this source of pollution, and washes the filth into Fresh Pond, may be clearly seen by the above measurements, which were taken by order of the city engineer. It will also be noticed, that

at times the amount of surface-drainage discharged from this source into Fresh Pond may exceed 1,500,000 gallons in a single day. During the dry seasons, the surface-washings are collected in Richardson's Pond, the water of which is very filthy, especially that which has remained in the pond for some time: this may be seen by the analyses in the table. All of these analyses were of water taken from the outlet during the rainy season, with one exception, viz., the one dated July 8, 1879, at which time the outlet was dry, and the specimen was collected from the pond itself. This analysis shows an exceedingly filthy condition of the water in the pond, which was destined to be washed into Fresh Pond by the next heavy rain. Most of the pollution in this pond must come from highly-manured land, and from Mr. Hittinger's piggery, in which there are, however, at the present time (August), but three pigs kept. No night-soil is used upon the Hittinger farm, and none upon the district, so far as I have been able to learn.

It seems to me that water flowing into Fresh Pond at the rate of more than 1,500,000 gallons in a single day at this point, and flowing out through the pumping-conduit at a somewhat greater rate, must tend at times to create a slight current in the pond, from the Cushing-street sources of pollution toward the end of the pumping-conduit, thereby at certain seasons increasing the chance of polluting the water in the city pipes with any germs of disease which may have been washed into and from Cider-mill Pond from the privies and cesspools.

The future of the district drained by Richardson's Pond presents no more favorable aspect than the present. It is not probable that the number of inhabitants, or the amount of highly-cultivated land, will be at all diminished, but they will rather increase; and, although there may be no night-soil used upon the land in this district at present, it is no guaranty that there will be none in the future.

The danger to Fresh Pond water from the two sources of pollution mentioned above is very great, and the only safety lies in diverting all of this surface-drainage from Fresh Pond by means of a sewer, the proper location of which belongs to the province of the civil engineer.

Alewife Brook, with its entering sewers, is another danger-

ous source of pollution of Fresh Pond. This brook was formerly the outlet of Fresh Pond; but, since so large an amount of water has been drawn from the pond for the supply of Cambridge, the level of the pond has much of the time been lower than that of the brook, and the water has tended to flow from the brook to the pond. A gate was therefore constructed to prevent this, and later a brick bulkhead was built in the gate-house. In addition to these obstructions to the flow of water between the pond and brook, a sheet-piling dam has been constructed across the brook, so that there is no danger of any *direct* communication between these two bodies of water; but a considerable amount of the impurities from the brook gets into the pond by percolation through the soil, as shown by the analysis of the water from well No. 29.

At the present time Alewife Brook is simply an open sewer, discharging its filth into the lower Mystic basin, and contaminating the atmosphere throughout its entire length with offensive and deleterious gases, and the subsoil with its sewage.

The first sewer which discharges its contents into Alewife Brook is the Concord-avenue sewer, which drains 298.21 acres in Cambridge, but at present receives the sewage from only a very few (ten) houses, and from the engine-house of the water-works, the waste from which (200,000 gallons daily) keeps it well flushed. This sewer empties into Alewife Brook at Concord Avenue, and its sewage is at present very dilute in comparison with that of most sewers; but it must nevertheless be to a certain extent dangerous, since the sewage is discharged within so short a distance (about 400 feet) from the border of the pond, that some of the filth is liable to soak through the soil into the pond. Moreover, this subsoil flow toward the pond must be quite rapid at this point, since wells driven at the border of the pond show a pressure of from two to four inches of water above the level of the pond.[1]

The next sewer which drains into Alewife Brook is that from Niles Brothers' slaughter-house, the sewage from which

[1] In well No. 14, at Black's Nook, the water stood three inches higher than the water in the pond. In well No. 16 it stood two inches, and in well No. 18 two and one-half inches.

is discharged through a three-inch pipe into the brook, a few rods north of the Fitchburg Railroad track. This contains the blood and offal from the pig-slaughtering establishment, mixed with a little carbolic acid. The brook at this point is exceedingly vile and offensive, and contaminates the subsoil for some distance, so that the water from a well sunk about fifteen feet from the brook smelled distinctly of the carbolized sewage. The air also for a considerable distance from this point is very offensive; and the filth often flows in both directions, backing up at times as far as Concord Avenue. The peculiar odor was distinctly perceptible at Concord Avenue at the time of my last visit, July 29; that is, the water had backed up as far as the mouth of the Concord-avenue sewer, and there was no perceptible current in the brook.

Lower down, the Spruce-street sewer empties into Alewife Brook, discharging the drainage from 382.92 acres of territory which is tolerably thickly settled. This sewage is mixed with a large amount of water from the clay-pits, which gives it a whitish appearance, and which probably unites with and neutralizes a certain amount of the sewage.

Under the bridge which passes over Alewife Brook on North Avenue empties the North-avenue sewer, which drains 182.64 acres of a very thickly-settled district, and discharges very objectionable material into the brook, consisting of not only a large amount of human excreta, but also the refuse from two slaughter-houses, one of which is situated in Cambridge and the other in Somerville. The brook at this point is stained red with blood from these establishments. Probably but very little of this sewage affects the water of Fresh Pond, on account of the distance between the two points, and since the flow of the brook at this point is quite rapid; but it renders the neighborhood offensive from decomposition of the animal matter. Such sewage as this should never be allowed to flow through an *open* sewer.

Between North Avenue and Broadway the brook receives the refuse from the tanneries of William Muller and others. This refuse is conducted from the tanneries through an open ditch. The same objection applies to this sewage as to that from the North-avenue sewer. The filth from these sources may sometimes be seen at the tide-gates on Broadway in considerable quantities, and much complaint has been made by the residents in this vicinity.

The water at the lower end of Alewife Brook is largely diluted with the water of Little River, which is the natural outlet of Little and Spy Ponds and Wellington Brook, so that the brook does not appear as foul below the entrance of Little River as in the vicinity of Fresh Pond. An examination of the water near the opening of the various sewers may be found in the table.

During wet seasóns Alewife Brook overflows its banks, and the filth is spread for a considerable distance over the meadows, from which the water sooner or later finds its way into Fresh Pond.

The sewage from all of these points is sure to increase rather than diminish, especially that in the Concord-avenue sewer, and must be diverted, in order to prevent dangerous sewage from getting into Fresh Pond, if it is decided to continue the use of Fresh Pond as one of the sources of water-supply for the city of Cambridge. All of this sewage may be easily diverted by means of a tight sewer emptying into tide-water. Such a sewer has for a long time been recommended by the city engineer, and should be constructed under any circumstances, even though Fresh Pond were not used as a source of water-supply, for other and obvious sanitary reasons.

Black's Drainage. — On the western side of Fresh Pond, near the railroad-track leading to the ice-houses, is a bog-hole, which receives indirectly the drainage from the late Mr. Black's house and one or two other houses in the vicinity, with their annexed stables, pigsties, hen-houses, &c. This bog empties directly into Fresh Pond (Black's Nook) through a culvert under the railroad-track. This drainage could also be conducted to a sewer connected with the Concord-avenue sewer. An analysis of this water may also be found in the table.

Fresh Pond Hotel and the adjoining grounds, which are used so largely for picnic-parties, undoubtedly furnish a certain amount of sewage for Fresh Pond. "There is no direct drainage into the pond, either from the grove or from the hotel connected with it; but undoubtedly the pond receives a considerable amount of impurities from the presence on its banks of such large numbers of people."[1] The vault

[1] Report on the Sanitary Condition of Cambridge, by Edward R. Cogswell,

sometimes overflows, in which case the sewage is washed into the pond. This should, of course, be prevented.

Additional Water-Supply.

Wellington Brook. — This brook receives a large amount of impurities from the territory draining into it, which is very extensive, its drainage-area being about two thousand five hundred acres. It rises between Belmont and North Streets, near their junction with Common Street, about opposite the Cushing estate, flows down toward the Fitchburg Railroad track in Waverley, then alongside of the track to the Belmont station, from which point it crosses the lowlands, passing under Brighton Street, and empties into Little River. A short distance from Brighton Street it crosses the conduit, into which it can be turned or not at pleasure.

Before reaching the Belmont railroad-station, it receives a large amount of drainage, direct and indirect, from buildings near the bank. Formerly the sewage from the privies and sinks was discharged directly into the brook, the privies in many instances being built over the brook; these were moved back as far as possible, and brick vaults provided for the inhabitants by the Water Board, so that, at the present time, the *privy*-drainage in this district is indirect. A considerable amount of house-drainage, however, still goes directly into the brook. After leaving the railroad-track it enters the lowlands, which are highly cultivated and manured, partly with night-soil. In its flow through these market-gardens it necessarily takes up a large amount of animal matter, especially after a heavy rain. How much of this is human, depends largely upon the amount of night-soil used as manure, which varies according to circumstances.

A short distance from Brighton Street it receives the drainage from Richardson's piggery, about which so much has been said in the various Water Board reports. Formerly the drainage from this piggery was received into the brook by an open ditch, which has been filled up, and a dike built, so that it is now obliged to flow over the meadow, or soak through the soil, before entering the brook. "After a heavy rain, however, the water rises high enough to overflow this

M.D. From the Ninth Annual Report of the State Board of Health of Massachusetts, p. 336.

dike; and, for the time at least, this attempt to divert the drainage of the piggery is rendered abortive."[1] That portion of the drainage which soaks into the ground must also sooner or later find its way into the brook; since the flow of the subsoil water must be toward the brook, and the earth can only act as a purifier for a short time when water containing a very large amount of sewage percolates through it.

A more recent source of pollution is Niles Brothers' "muck-heap," upon which all of the "soup" from the slaughter-house is thrown for the purpose of making manure. This muck-heap is situated on the top of a gravel-bank, west of the slaughter-house, between it and Wellington Brook. During the warm weather, when the ground is not frozen, the muck will absorb very large quantities of soup, so that, if the muck-heap is properly taken care of, there is no danger of pollution of the water of the brook or of the subsoil. In the winter, however, the soup cannot be absorbed, and must flow down the hillside to Wellington Brook. This matter is, however, under the supervision of the State Board of Health, in whose hands it may safely be left.

Little Pond. — Little Pond is connected with Fresh Pond by the conduit: it receives *directly* the drainage of thirty-four acres of highly-cultivated land, and is surrounded by market-gardens upon which a large amount of night-soil is used. A portion of this must be washed into the pond by heavy rains, and another portion must also get into the pond by percolation. During the construction of the filter-basin at the side of the pond, it happened that the surface of the pond was lowered a few inches by the pumps which were used to remove the water from the basin; and it was noticed that, whenever the surface of Little Pond was lowered, the wells in the neighborhood, quite a long distance away, were dried up, thus showing the extent and rapidity of the subsoil flow.

Little Pond is fed not only by the springs supplied with water from the surrounding territory, but by two brooks, which rise upon Arlington Heights: one of these is known by the name of Frost Brook. These brooks supply by far the largest amount of the water of Little Pond, and increase very largely its drainage area. At the source of these

[1] Dr. Cogswell's Report, *loc. cit.*, p. 341.

brooks the water is very pure; but in its flow through the cultivated land upon the hillside, and through the market-gardens below Pleasant Street, upon which a large amount of night-soil is used, it takes up a considerable quantity of organic matter, as may be seen by the analyses of specimens of water taken from Frost Brook in different portions of its course at the same time. A large amount of manure is washed into these brooks from the land by heavy rains, so that at times they are colored dark brown with the coloring matter from the manured land.

The following measurements, which were taken at a weir constructed at the inlet of Little Pond, show the amount of polluted water which is discharged into the pond from these brooks: —

1879.	Gallons.	Rainfall in Inches.	1879.	Gallons.	Rainfall in Inches.
April 2	3,983,772	2.11[1]	May 9	1,428,570	–
" 9	1,573,830	–	" 10	1,343,878	–
" 10	1,544,328	1.26	" 11	1,260,624	–
" 11	3,868,751	0.03	" 12	1,152,562	–
" 12	2,271,422	–	" 13	1,073,715	–
" 13	1,940,983	–	" 14	777,708	–
" 14	2,101,390	–	" 15	686,155	–
" 15	2,604,179	0.32	" 16	686,155	0.04
" 16	2,775,877	0.03	" 17	731,158	0.19
" 17	2,068,975	0.72	" 18	686,155	–
" 18	4,413,087	0.81	" 19	577,392	0.76
" 19	3,868,751	0.07	" 20	1,288,257	0.08
" 20	3,641,850	–	" 21	1,073,715	0.12
" 21	3,345,390	–	" 22	1,515,073	–
" 22	2,950,679	–	" 23	1,022,281	–
" 23	2,741,462	–	" 24	896,883	–
" 24	2,402,815	–	" 25	620,137	–
" 25	2,336,542	0.02	" 26	796,036	–
" 26	2,238,890	–	" 27	620,137	–
" 27	2,068,975	–	" 28	598,660	0.02
" 28	1,940,983	0.54	" 29	535,638	–
" 29	3,200,535	0.96	" 30	495,048	–
" 30	5,347,585	0.15	" 31	436,084	–
May 1	3,200,535	–	June 1	556,465	–
" 2	2,536,323	–	" 2	361,447	0.24
" 3	2,199,667	–	" 3	515,166	0.74
" 4	1,972,786	–	" 4	754,380	0.37
" 5	1,940,983	0.01	" 5	796,036	0.43
" 6	1,784,886	–	" 6	777,708	0.10
" 7	1,544,328	–	" 7	686,155	0.03
" 8	1,428,570	–	" 8	495,048	–

[1] During past week.

1879.	Gallons.	Rainfall in Inches.	1879.	Gallons.	Rainfall in Inches.
June 9 .	455,440	0.04	June 20 .	343,444	-
" 10 .	495,048	0.03	" 21 .	291,577	-
" 11 .	416,994	-	" 22 .	274,920	-
" 12 .	379,668	0.05	" 23 .	242,632	-
" 13 .	416,994	-	" 24 .	181,163	-
" 14 .	308,587	0.08	" 25 .	181,163	-
" 15 .	398,185	1.03	" 26 .	91,414	-
" 16 .	1,047,851	0.01	" 27 .	140,758	-
" 17 .	598,660	-	" 28 .	91,414	-
" 18 .	416,994	-	" 29 .	127,761	0.23
" 19 .	361,447	-			

This water, as a rule, flows directly through Little Pond to its outlet, Little River, which crosses the meadows, unites with Wellington Brook, and empties into Alewife Brook, as mentioned above. But little of the water, fortunately, has been taken into the conduit, an uninterrupted flow from the pond to the conduit being prevented by a gate, which has been open but little since the construction of the conduit. Most of the water passing through the conduit is derived from the filter-basin, the water of which, of course, differs from Little Pond water in containing no surface water, but only that which has percolated through the soil. The surroundings of the filter-basin are naturally as objectionable as those of the pond, with the single exception that it is not liable to become polluted with surface washings by heavy rains. It is, however, as liable to become contaminated as a surface well dug in the midst of highly-manured fields: no sanitarian would think of recommending the use of a well so situated for drinking purposes, especially if a large portion of the manure used upon the fields consisted of night-soil, and therefore contained *human* excreta. Upon a single farm in this neighborhood from fifty to sixty loads of night-soil are used annually as manure, and it is probable that a corresponding amount is used upon the others.

The future prospect of this district drained by Little Pond with its entering brooks, and Wellington Brook, which constitute the sources of the additional water-supply for the city of Cambridge, is more unfavorable than the present, and with no possibility of being remedied. With the rapidly increasing demand for water, these sources must be drawn upon to a still

greater extent than heretofore, unless some other source of supply be obtained in their place. The population in this district is constantly increasing, and the amount of land which is highly tilled is also constantly increasing. Even within the last two years a large amount of new land upon the side of the Arlington hills, near the head waters of Frost Brook, has been broken up for high cultivation. And, again, the amount of night-soil used upon the gardens in this district is almost sure to increase: the owner of one of these gardens told me that he used all of the night-soil which he could get, and would gladly use more, but could not obtain it.

As to remedy, it is obviously impossible for the city of Cambridge to control the whole territory drained by Wellington Brook and Little Pond; and, if the city could control it, it would be decidedly unwise to interfere with so extensive a business as that of "market-gardening," which is the most important source of pollution of the water in this district. Even if this business were entirely stopped in the district drained by these sources of water-supply, all of the land suitable for the erection of dwelling-houses would undoubtedly, in a few years, be densely populated, and thereby not at all improved in character as a gathering-ground for a source of water-supply. The only safe remedy seems to me to discontinue altogether the use of Little Pond and Wellington Brook, the waters of which cannot fail to add impurities to Fresh Pond water to an extent and of a character which may prove dangerous to the health of the community.

The Conduit.[1] — As has been mentioned above, the conduit extends from Little Pond to Black's Nook. At the Little Pond end there is a gate through which the water from Little Pond may be allowed to flow if necessary. A short distance from Little Pond, water from the filter-basin is admitted to the conduit; and where the conduit crosses Wellington Brook a gate is constructed, so as to admit the water from the brook if desirable.

The water in the conduit is at times exceedingly impure, as may be seen by the analyses in the table. Most of the impurities must come from the filter-basin and the surrounding soil, since the conduit is not a tight one, but, on the contrary,

[1] For a full description of the conduit, see p. 128, and the map opposite p. 226, of the Tenth Report of the State Board of Health.

permits a large amount of water to leak into it. Gaugings taken by the city engineer show that this leakage amounts at times to from six hundred thousand to eight hundred thousand gallons per day between Wellington Brook and Fresh Pond.[1] For a portion of its course the conduit is situated only a few feet below the surface of the ground; so that the water which leaks in is simply the bog-water which covers the meadows, and which always contains a large amount of vegetable matter.

A possible future source of contamination of the water in the conduit is Niles Brothers' slaughter-house, which, although it is constructed so as to be tight, and to prevent, as far as possible, any soakage of animal matter into the ground, acts indirectly as a serious source of pollution, by attracting to its neighborhood a number of workmen, for whom buildings have been erected, from which the house-drainage is poured onto or into the surrounding earth. In case of certain accidents at the slaughter-house, a large amount of animal matter might be cast upon the ground, from which much might easily get into the pond or into the conduit; any accident which would cause a leakage from the buildings, or from certain apparatus outside of the buildings, such as the bursting of the pipe which conducts the "soup" to the "muck-heap," breaking of the drain-pipe leading to Alewife Brook, cracking of the cemented floors in some of the buildings, negligence of the proper precautions in the transportation of the pigs, or, lastly, the partial destruction of the buildings by fire, might result in the contamination of the water in Fresh Pond by animal matter in two ways: either by soaking into the conduit, which is very near the surface of the ground at this point, or by soakage through the subsoil to the pond. Recent investigations made by the city engineer show that the pressure was such that the subsoil water at Black's Nook — that portion of Fresh Pond nearest the slaughter-house — rose from two to four inches above the level of Fresh Pond, so that the flow of the subsoil water in the direction of the pond at this point must be quite rapid. Moreover, the filthy character of the water in the conduit, when the gates were closed at both Little Pond and Wellington Brook, and yet when a large amount of water was flowing into the pond from the conduit, which water must have consisted of the average subsoil water

[1] See footnote on p. 84.

at that time, shows that the upper stratum of gravel, at all events, no longer acts as an efficient filter.[1]

Fresh-pond Meadows. — The borings which have recently been made under the supervision of the city engineer show that there is a very rapid flow of the water under these meadows toward Fresh Pond, and, therefore, that a considerable portion of the supply for the pond comes from the meadows by percolation through the earth. This shows the necessity of keeping the surface of the meadows as free from pollution as possible.

Of the present sources of contamination some have already been mentioned in the foregoing pages. The most important one is Alewife Brook with its sewers; the filth from this source is spread over the meadows for a considerable distance during wet seasons, and can only be prevented by removing the sewage from the brook. The slaughter-house of Niles Brothers, with its drain-pipe, has also been spoken of. This drain-pipe has already broken several times, when a large quantity of sewage has been poured on to the surface, discoloring the water for a long distance. In addition to these, there are a number of buildings situated on the meadows, from which offensive material is discharged; but there are few or none of these situated near Fresh Pond.

All possible means should be taken to prevent the discharge of noxious material upon this district, especially in the neighborhood of the pond, since the water must find its way very quickly to the pond. The natural meadow-water contains a large amount of vegetable matter, which is removed by filtration and storage; but we cannot be certain that the animal matter is so completely removed, especially that which contains human excrement; and such material is poured over the meadows from Alewife Brook and Little River.

[1] Measurements made by Mr. Barbour in July, 1876, showed that the leakage into the conduit between Wellington Brook and the pond was at the rate of 1,071,924 gallons; on Nov. 19, 1878, between Little and Fresh Ponds, it was 1,829,952 gallons after a heavy rain; on Nov. 16, 1878, it was 995,036 gallons; on Dec. 6, 1878, between Little Pond and Wellington Brook, it was 588,586 gallons; on Dec. 16, 1878, between Little Pond and Wellington Brook, it was 520,148 gallons, and for the whole length of the conduit 1,113,294 gallons, making the leakage into the conduit between Wellington Brook and Fresh Pond 593,146 gallons; on Dec. 18, 1878, between Wellington Brook and Fresh Pond, it was 846,377 gallons, and on Dec. 19 it was 858,924 gallons. (Report of Evidence in the case of the City of Cambridge *v.* Niles Brothers: Tenth Annual Report of the State Board of Health of Massachusetts, pp. 130, 131.)

Table of Water Analyses.

Fresh Pond.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue.			Chlorine.	Hardness (degrees).
					Inorganic.	Organic and Volatile.	Total.		
1853.									
July .	Mariner .	. . . . . .	–	–	8.51	2.31	10.82	1.95	–
1872.									
Oct. .	Sharples .	. . . . . .	–	–	16.49	5.00	21.49	–	–
1873 .	Horsford .	. . . . . .	–	–	9.72	4.05	13.77	–	–
1875.									
Feb. 22 .	Sharples .	Top	0.0170	0.0155	8.00	5.00	13.00	1.99	–
" 22 .	" .	Bottom	–	–	9.00	5.00	14.00	–	–
Mar. 12 .	" .	Service	–	–	9.00	4.00	13.00	–	–
June 2 .	" .	"	0.0010	0.0050	11.00	3.00	14.00	–	–
" 16 .	" .	"	0.0010	0.0050	9.50	3.00	12.50	–	–
1876.									
Mar. 13 .	" .	"	0.0048	0.0086	10.00	4.20	14.20	1.63	–
Aug. 8 .	" .	. . . . . .	0.0010	0.0165	8.00	5.00	13.00	–	–
Dec. 13 .	" .	Top	0.0160	0.0160	10.50	3.50	14.00	–	–
" 16 .	" .	Service	0.0048	0.0060	9.00	3.50	12.50	–	–
1877.									
April 4 .	" .	Engine-house . .	0.0080	0.0096	8.00	4.00	12.00	–	–
Sept. 4 .	Nichols .	. . . . . .	0.0061	0.0197	10.90	1.50	12.40	1.70	–
" 4 .	" .	Service	0.0051	0.0248	–	–	–	1.20	–
Oct. 1 .	Sharples .	. . . . . .	0.0050	0.0148	10.00	3.50	13.50	–	–
" 1 .	" .	Service	0.0016	0.0165	10.00	4.50	14.50	–	–
" 1 .	" .	Reservoir . . .	0.0050	0.0198	9.70	5.30	15.00	–	–
" 18 .	Nichols .	Top	0.0144	0.0234	11.05	1.10	12.15	2.10	–
" 18 .	" .	Bottom [1]	0.2592	0.0368	13.45	1.75	15.20	–	–
Nov. 14 .	" .	Top	0.0419	0.0179	11.90	2.40	14.30	1.81	–
" 14 .	" .	Bottom	0.0429	0.0179	11.90	1.10	13.00	1.64	–
Dec. 12 .	" .	"	0.0267	0.0243	–	–	–	1.89	–
" 12 .	" .	"	0.0264	0.0248	–	–	–	1.87	–
" 12 .	" .	"	0.0264	0.0212	–	–	–	1.82	–
" 12 .	" .	"	0.0264	0.0171	–	–	–	1.78	–
" 12 .	" .	"	0.0264	0.0177	–	–	–	1.84	–
" 12 .	" .	"	0.0269	0.0165	–	–	–	1.85	–
1878.	" .								
May 4 .	" .	S.W. buoy [2] . . .	0.0021	0.0176	–	–	12.4	1.41	–
" 14 .	" .	" " . . .	0.0027	0.0149	–	–	13.1	1.23	–
June 4 .	" .	" " . . .	0.0045	0.0155	–	–	16.1	1.41	–
" 12 .	" .	N.E. " . . .	0.0027	0.0155	–	–	13.3	1.31	–
" 19 .	" .	S.W. " . . .	0.0027	0.0129	–	–	13.7	1.38	–
" 25 .	" .	N.E. " . . .	0.0035	0.0285	–	–	15.6	1.47	–
July 2 .	" .	S.W. " . . .	0.0039	0.0251	–	–	14.7	1.47	–
" 9 .	" .	N.E. " . . .	0.0035	0.0184	–	–	13.8	1.38	–
" 16 .	" .	S.W. " . . .	0.0029	0.0203	–	–	13.2	1.30	–
" 23 .	" .	N.E. " . . .	0.0021	0.0173	–	–	13.2	1.40	–
Aug. 6 .	" .	" " . . .	0.0037	0.0197	–	–	11.7	1.44	–
" 13 .	" .	S.W. " . . .	0.0045	0.0216	–	–	12.0	1.37	–
" 20 .	" .	N.E. " . . .	0.0045	0.0195	–	–	11.0	1.36	–
" 27 .	" .	S.W. " . . .	0.0024	0.0202	–	–	11.7	1.31	–
Oct. 21 .	" .	N.E. " . . .	0.0181	0.0166	–	–	13.3	1.46	–
Nov. 7 .	" .	S.W. " . . .	0.0309	0.0173	–	–	11.5	1.22	–
" 14 .	Sharples .	Engine-house . .	0.0224	0.0224	10.5	3.00	13.5	–	–
Dec. 7 .	Nichols .	N.E. buoy . . .	0.0296	0.0234	–	–	12.6	1.30	–
1879.									
Feb. 1 .	Sharples .	. . . . . .	0.0128	0.0192	9.00	3.00	12.00	–	–
" 8 .	Wood .	Black's Nook . .	0.0400	0.0290	10.50	8.00	18.50	2.35	7½
Mar. 19 .	" .	Drain from Black's house [3] . . .	0.0132	0.0580	1.50	3.50	5.00	0.4	1

[1] "This specimen of water was offensive to the taste and smell when taken from the pond. It probably came from the neighborhood of a mass of decaying matter. The result of six attempts to obtain another similar specimen on Dec. 12, 1877, is seen above.

These samples marked S.W. buoy and "N.E. buoy" were taken two feet below the surface, at one or the other of two points several hundred feet apart, at the mouth of the bay from which the [pumping] conduit issues."

[3] A foul odor like that of kitchen-slops.

Table of Water Analyses — Continued.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1879.									
Mar. 28.	Wood	Engine-house[1]	[illegible]	[illegible]	[illegible]	7.00	[illegible]	1.6	5
" 28.	"	Bar opposite Hunnewell's ice-house	[illegible]	[illegible]	5.00	[illegible]	[illegible]	1.6	6
Aug. 5.	Sharples	Near mouth of pumping conduit	[illegible]	[illegible]	[illegible]	[illegible]	11.50	–	–
" 5.	"	Service	[illegible]	[illegible]	[illegible]	3.00	11.00	–	–

CUSHING-STREET DISTRICT.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1877.									
April 4.	Sharples	Cider Mill Pond	0.0190	[illegible]	9.50	7.50	17.00	–	–
Dec. 21.	"	" "	0.0046	[illegible]	6.00	10.50	16.50	–	–
1878.									
Mar. 20.	"	" "[2]	[illegible]	0.1306	14.00	8.00	22.00	–	–
" 20.	"	" "[3]	–	–	30.00	5.00	35.00	–	–
Aug. 3.	"	" "	0.0032	0.1440	9.00	9.00	18.00	–	–
1879.									
Mar. 19.	Wood	" "[4]	0.0800	0.0490	2.25	3.25	5.50	1.0	1¼
April 29.	"	" "	0.0014	0.0500	3.00	3.50	6.50	1.5	1
July 8.	"	" "[5]	0.0006	0.0610	2.25	10.00	12.25	1.6	1¼
Feb. 13.	"	Richardson's Pond outlet	0.0160	0.0260	5.00	6.00	11.00	0.7	2¼
Mar. 10.	"	Richardson's Pond outlet	0.0196	0.0240	5.50	6.00	11.50	0.9	3
April 29.	"	Richardson's Pond outlet	0.0032	0.0226	7.50	7.00	14.50	1.2	3¼
May 12.	"	Richardson's Pond outlet	0.0106	0.0172	7.00	7.50	14.50	1.2	4
July 8.	"	Richardson's Pond[5]	0.0532	0.0534	6.50	8.00	14.50	1.2	3¼
Feb. 13.	"	Bridge	0.0400	0.0260	6.00	6.00	12.00	1.30	3
April 29.	"	"	0.0040	0.0250	6.00	6.50	12.50	1.50	4

WELLINGTON BROOK.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1875.									
June 16.	Sharples	. . . . .	0.0020	0.0090	7.50	3.00	10.50	–	–
1876.									
Dec. 13.	"	Above pigsties	0.0048	0.0064	7.50	3.50	11.00	–	–
" 13.	"	Below "	0.0048	0.0064	7.00	3.00	10.00	–	–
1877.									
April 4.	"	Above gate-house	0.0064	0.0080	4.50	3.70	8.20	–	–
Aug. 30.	Nichols	. . . . .	0.0125	0.0237	8.70	3.30	12.00	1.75	–
Sept. 7.	"	. . . . .	0.0088	0.0189	9.10	3.20	12.30	1.20	–
Oct. 1.	Sharples	. . . . .	0.0050	0.0066	8.70	4.00	12.70	–	–
" 6.	Nichols	. . . . .	0.0280	0.0544	–	–	14.90	1.10	–
" 6.	"	Opposite pigsties	0.0272	0.0680	12.60	3.90	16.50	1.00	–
" 6.	"	At conduit	0.0243	0.0483	13.10	4.60	17.70	1.70	–
1879.									
Mar. 29.	Wood	Brighton Street	0.0186	0.0268	5.50	5.50	11.00	1.00	2¼
July 8.	"	"	0.0160	0.0200	6.00	6.00	12.00	1.10	3¼
" 8.	"	Belmont Street	0.0620	0.0246	6.50	8.50	15.00	1.20	3

[1] The demijohn had a badly-fitting stopper, which may have affected the result of the analysis, especially the free ammonia. [2] Filtered. [3] Unfiltered. [4] Very foul odor. [5] Outlet dry.

Table of Water Analyses — Continued.

LITTLE POND.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1875.									
June 2.	Sharples	Top	0.0016	0.0110	8.70	4.50	13.20	–	–
1876.									
Mar. 13.	"	Springs.	0.0064	0.0064	13.20	6.80	20.00	1.92	–
" 13.	"	" [1]	0.0128	0.0120	13.40	6.60	20.00	2.57	–
" 13.	"	" [2]	0.0088	0.0080	18.00	4.50	22.50	2.60	–
Aug. 9.	"	Filter basin	0.0254	0.0231	12.00	6.00	18.00	2.21	–
Dec. 13.	"	Top	0.0070	0.0120	8.00	6.00	14.00	–	–
" 13.	"	Filter basin	0.0080	0.0054	14.00	4.50	18.50	3.09	–
1877.									
Aug. 30.	Nichols	. . . . . .	0.0261	0.0624	–	–	–	3.10	–
Sept. 7.	"	. . . . . .	0.1312	0.0981	13.30	5.80	19.10	2.60	–
Oct. 1.	Sharples	. . . . . .	0.0165	0.0165	14.20	4.50	18.70	–	–
1879.									
Mar. 20.	Wood	Top	0.0133	0.0900	4.25	5.25	9.50	1.20	2½
" 26.	"	"	0.0160	0.0320	5.50	4.75	10.25	1.20	2½
Feb. 1.	Sharples	Under ice	0.0160	0.0226	7.00	4.00	11.00	–	–

FROST BROOK.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1879.									
Mar. 29.	Wood	Clifton Street	0.0080	0.0178	6.00	2.00	8.00	0.60	2
" 29.	"	Brighton Street	0.0880	0.0228	4.50	5.50	10.00	1.00	2½
May 12.	"	Arlington Heights	0.0052	0.0092	1.50	2.00	3.50	0.40	1
" 12.	"	Brighton Street	0.0106	0.0126	3.50	5.00	8.50	1.00	2½
July 8.	"	Clifton Street	0.0106	0.0250	5.00	4.50	9.50	0.80	1½
" 8.	"	Brighton Street	0.0106	0.0300	4.25	7.00	11.25	1.3	2½

CONDUIT WATER.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1877.									
Oct. 1.	Sharples	. . . . . .	0.0040	0.0066	15.00	5.50	20.50	–	–
Dec. 21.	"	. . . . . .	0.0010	0.0127	9.50	3.00	12.50	–	–
1878.									
Aug. 29.	"	Manhole near Black's gate-house	0.0128	0.0128	13.00	5.00	18.00	–	–
Nov. 14.	"	Near Fresh Pond	0.0128	0.0128	16.50	5.00	21.50	–	–
Dec. 16.	"	Third and first manhole,	0.0062	0.0047	17.00	3.00	20.00	–	–
1879.									
Feb. 27.	Hills	First manhole [3]	0.0174	0.0150	10.00	7.00	17.00	3.8	8
" 27.	"	Fourth "	0.0186	0.0170	10.00	8.00	18.00	4.0	9
" 27.	"	Fifth "	0.0200	0.0100	13.00	10.00	23.00	3.8	10
" 27.	"	Seventh "	0.0120	0.0090	11.50	7.10	18.60	4.0	10
Mar. 20.	Wood	First manhole west of Wellington Brook [4]	0.0212	0.0100	11.00	7.75	18.75	2.3	9½
" 26.	"	First manhole west of Wellington Brook	0.0160	0.0190	10.00	7.75	17.75	1.9	8

[1] Unfiltered. [2] Filtered. [3] These manholes are numbered from Fresh Pond toward Little Pond. [4] The demijohn had a badly-fitting stopper, which may have affected the result of the analysis, especially the free ammonia.

Table of Water Analyses — Concluded.

SPY POND.

Date.	Analyst.	Locality.	Free Ammonia.	Albuminoid Ammonia.	Residue. Inorganic.	Residue. Organic and Volatile.	Residue. Total.	Chlorine.	Hardness (degrees).
1870 .	Horsford .	Outlet	–	–	9.60	6.40	16.00	–	–
1875.									
Feb. 22 .	Sharples .	Top	0.0124	0.0217	12.00	5.00	17.00	2.53	–
" 22 .	" .	Bottom	–	–	12.00	5.00	17.00	–	–
June 16 .	" .	Top	0.0060	0.0090	11.70	3.00	14.70	–	–
1876.									
Dec. 13 .	" .	"	0.0192	0.0192	9.50	4.70	14.20	–	–
1877.									
Aug. 30 .	Nichols .	. . . . . .	0.0040	0.0539	10.60	2.80	13.40	3.40	–
Oct. 1 .	Sharples .	. . . . . .	0.0033	0.0231	9.50	6.00	15.50	–	–
1879.									
Feb. .	" .	. . . . . .	0.0640	0.0128	13.00	4.00	17.00	–	–

ALEWIFE BROOK.

1875.									
June 16 .	Sharples .	. . . . . .	0.0050	0.0120	9.50	4.50	14.00	–	–
1879.									
July 29 .	Wood .	Spruce-street sewer .	0.4800	0.0580	15.75	15.75	31.50	5.50	12¼
" 29 .	" .	North-avenue " .	0.2880	0.0560	7.75	12.75	20.50	5.10	9
" 28 .	" .	Concord-avenue " .	0.2160	0.0290	9.75	5.50	15.25	3.75	7½
" 28 .	" .	Niles Brothers' " .	1.1520	0.0650	27.75	19.50	47.25	19.50	11½

WELLS ON MEADOWS.[1]

1879.									
July 28 .	Wood .	Well No. 14[2] . .	–	–	–	–	–	2.60	–
" 29 .	" .	" 14 . .	–	–	–	–	–	2.75	–
" 28 .	" .	" 10[3] . .	–	–	27.75	30.00	57.75	8.25	–
" 29 .	" .	" 17[4] . .	–	–	30.50	9.50	40.00	8.25	–
Aug. 6 .	" .	" 14 . .	0.0021	0.0046	20.00	14.75	34.75	2.70	16¼
" 6 .	" .	" 19[5] . .	0.0074	0.0036	23.75	5.75	29.50	6.30	12
" 15 .	" .	" 11[6] . .	0.1440	0.0420	37.25	17.75	55.00	18.50	20
" 15 .	" .	" 29[7] . .	0.3840	0.1400	13.00	13.00	26.00	2.90	14

[1] Borings recently made under the supervision of the city engineer. [2] On the edge of Fresh Pond, at Black's Nook. The water in this well stood three inches above the level of Fresh Pond. [3] At the side of Alewife Brook, between North Avenue and Broadway. This was a deep well from below a very thick stratum of clay. A large amount of gas was discharged with the water. [4] On the meadows, about 50 feet north of Concord Avenue. [5] On the edge of Fresh Pond, near Tudor's ice-house. [6] Fifteen feet from Alewife Brook and from the mouth of the sewer of Niles Brothers' slaughter-house. [7] Between Concord Avenue and Fresh Pond, 15 feet from Alewife Brook, and about 350 feet from the pond.

NOTE. — The figures in the tables, with the exception of the degrees of hardness, express parts per 100,000 of water.

Fresh Pond.— Frankland and Armstrong Method.

By Prof. William Ripley Nichols.

Date.	Approximate depth.	Organic Carbon.	Organic Nitrogen.	Ratio Carbon / Nitrogen.
1879.				
Jan. 22.	20 feet[1]	0.174	0.048	3.6
" 22.	35 "	0.136	0.049	2.8
April 14.	2 "[2]	0.775	0.131	6.2
" 14.	20 "	0.915	0.146	6.3
" 14.	35 "	0.828	0.146	5.7
May 13.	2 "	0.308	0.045	6.9
" 13.	20 "	0.304	0.045	6.8
" 13.	35 "	0.258	0.038	6.8
June 12.	2 "	0.275	0.053	5.2
" 12.	20 "	0.289	0.064	4.5
" 12.	35 "	0.325	0.047	6.9
Average		0.417	0.074	5.6

[1] "Taken through the ice." [2] "Just after the ice had broken up."

I have collected in the above table all of the analyses of Fresh-pond waters which I have been able to find in the various reports upon the Cambridge water, and also some analyses performed by the Frankland and Armstrong method of water-analysis, which were kindly furnished me by Professor William Ripley Nichols of the Massachusetts Institute of Technology. The average composition of the Cochituate water, as determined by Professor Nichols, from January to June, 1879, was

Organic Carbon.	Organic Nitrogen.	Ratio Carbon / Nitrogen.
0.408.	0.052.	7.9.

The following figures, taken from the Sixth Report of the Rivers Pollution Commission, 1874, show the average composition of waters with which Fresh Pond may properly be compared: —

	Organic Carbon.	Organic Nitrogen.	Ratio Carbon / Nitrogen.
Average unpolluted upland surface water	0.322	0.032	10.1
The Teign above Old Wheal, Exmouth, Sept. 26, 1873,[1]	0.582	0.058	10.
Loch Katrine, Aug. 3, 1870[2]	0.185	0.022	8.4
The Thames, at Thames Ditton, Jan. 31, 1873[3]	0.325	0.076	4.3

[1] "A peaty water which contains more vegetable matter than is admissible for drinking." [2] "A very good water." [3] "Surface-water from cultivated land." "Certain amount of animal pollution. Nitrates and nitrites present from use of manures. Most efficient filtration needful."

The ratio of the carbon to the nitrogen is considered very important, as showing the nature of the organic matter, — whether of vegetable or animal origin. As a rule, especially in surface-waters, if the organic matter is of vegetable origin, this ratio is high, but, if of animal origin, the ratio is low; so that, as a rule, in the same class of waters, the higher this ratio the better the water. In this respect the analyses of Professor Nichols show the water of Fresh Pond to be at times somewhat inferior in quality to that of Cochituate; and a comparison of his analyses with those quoted from the Rivers Pollution Commission Report shows it to be inferior to the "average unpolluted upland surface-water," and to resemble more nearly the water of "the Thames at Thames Ditton," which is "surface-water from cultivated land," and contains a "certain amount of animal pollution," from the use of manure upon the surrounding gathering-ground.

By the Wanklyn and Chapman method of water-analysis, which is almost universally used in this country, and to a very large extent also in England, organic contamination is shown in surface waters chiefly by an excess of the free and albuminoid ammonia and chlorine, — an increase of the free ammonia and chlorine together indicating especially animal pollution, and the albuminoid ammonia alone vegetable contamination. Fresh-pond water contains a larger amount of chlorine, and is much harder, than other surface waters in this vicinity which are used as sources of water-supply; these properties it undoubtedly derives from the neighboring ground, which has, in former times, been saturated with sea-water. So far as the chlorine is concerned, therefore, we must not take into consideration its absolute amount, but only its increase over and above the average amount. Unfortunately there are not as many determinations of the chlorine in Fresh-pond water as of the free and albuminoid ammonia; but at times the chlorine is considerably increased, together with the ammonia; as, for instance, on Oct. 18 and Nov. 14, 1877, when all of these substances were increased more than usual.

It is, however, impossible to state with certainty whether the excess of chlorine found at certain times was due to the addition of a large amount of animal matter, or to an increased flow of water from the subsoil, as, for instance, from

the conduit. The analyses of the water derived from some of the recent borings near the pond, as well as those of the water which has leaked into the conduit from the surrounding earth, show that a considerable amount of water drawn from these sources would increase the chlorine in the pond. At the same time, the introduction into Fresh Pond of from one to three million gallons daily of water coming from highly cultivated land (from the Cushing-street district and the new conduit) would tend also to increase the ammonia.

The large increase in the amount of ammonia in the autumn may be explained in many ways. A portion may be due to decaying vegetation, but not the whole; since we do not observe so large an increase in other ponds, which are subjected to the same conditions as Fresh Pond, so far as decaying vegetation is concerned. It may also be partly explained by the surface-washings from the cultivated land, caused by the heavy rains in the fall and spring, at which seasons the manure is applied to the land.

The organic matter which is introduced into Fresh Pond through the various sources of pollution mentioned above partly disappears by decomposition, the volatile products of such decomposition escaping into the air, and the insoluble products being deposited as a sediment; and is partly disguised by being diluted with the purer water from the springs, which has been filtered through a long distance of gravel and sand; a portion also disappears in its passage through the distributing-pipes; a portion, however, escapes decomposition, and may be detected in the water drawn from the service-pipes, sometimes in too large an amount, as, for instance, on Sept. 4, 1877.

At the present time (August, 1879), the water is in excellent condition, as shown by the latest analyses (Aug. 6). This is, in my opinion, largely due to the fact that the pond has received no water directly from any of those sources of pollution which yield an abundant supply. The outlets of Cider-mill and Richardson's Ponds have been dry since about the 1st of July, and the gate at the mouth of the conduit has been closed during the entire summer. All of the analyses of water from the Cushing-street district show great pollution. In these waters the amount of chlorine is important, since they are surface waters, and, if unpolluted, would not

contain more than 0.3 or 0.5 parts in one hundred thousand. They contain less chlorine than Fresh Pond, and the excess above the above figures comes undoubtedly from sewage.

The analyses of Wellington-brook water simply confirm, what a careful inspection of the district would lead us to expect, viz., that at times, especially in the autumn, the water is very much polluted. This is shown particularly by the analyses of Professor Nichols on Oct. 6, 1877. The last analysis, on July 8, 1879, was taken from the spring at the side of the engine-house on Belmont Street. This spring forms the source of Wellington Brook, and is surrounded by highly-cultivated farms, from which it receives its supply; it was surrounded by a covered wooden casing, and is undoubtedly considered by the inhabitants in the neighborhood as a spring of excellent drinking-water. It was, however, at that time highly polluted; farther down it became diluted with a purer water, probably from the Waverley Hills, so that at Brighton Street it was less impure than at its source.

The analyses of Little-pond water show that, at times, it is liable to be very impure. This is shown especially by the analyses of the water in August and September.

The three sets of analyses of the water of Frost Brook are extremely interesting, as showing the influence of cultivated land upon a surface water. In only one of these, that of May 12, was the upper specimen taken from a point above all cultivated land: between this point and where the brook crosses Clifton Street it flows through ordinary farming-land, but between Clifton and Brighton Streets it flows through the highly manured market-gardens. The effect of these gardens in the early spring, when they are heavily manured, is well shown by the analyses of March 29, when the free ammonia was increased eleven times; at this time 1.67 inches of rain had fallen during the previous week, so that there must have been considerable surface washing into the brook.

The recent analyses of Alewife-brook water were made partly to determine the influence of the various sewers upon the brook. The impurities found at the mouth of the Concord-avenue sewer were, in part, undoubtedly due to the sewage from Niles Brothers' slaughter-house, the peculiar odor of which was plainly perceptible at Concord Avenue. Moreover, the Concord-avenue sewer receives the drainage

from only ten houses, and is flushed daily by about two hundred thousand gallons of water from the air-pump at the engine-house of the water-works. The water taken from the mouth of the Spruce-street sewer was unmixed with brook-water; but that marked "North-avenue sewer" was taken below the bridge, and was therefore diluted with the brook-water.

The "organic and volatile" residue from the water of the wells driven upon the borders of the pond and upon the meadows consisted chiefly of volatile inorganic matter; the residue did not char perceptibly upon being ignited, with the exception of that of wells Nos. 11 and 29, both of which show organic contamination from Alewife Brook. The water of well No. 11 was largely polluted with sewage from Niles Brothers' slaughter-house, although taken from the subsoil fifteen feet from the brook: that the sewage came from the slaughter-house, was very evident from the peculiar odor.

The water from well No. 29 was taken from just above the clay, and its analysis shows that it must have been polluted by sewage from the brook. This well is located about three hundred and fifty feet from the border of the pond.

Conclusions.

The careful survey of Fresh Pond and vicinity, and the study of the history of the Cambridge water-supply, in regard to which I have endeavored to give the principal facts in the foregoing pages, have led me to the following conclusions: —

1st, That Fresh Pond alone cannot be relied upon to furnish a sufficient supply of water for the city of Cambridge.

2d, That there are certain sources of contamination, which are liable to pollute the water of Fresh Pond to an extent dangerous to the health of the community, and which must be removed in order to preserve the purity of Fresh-pond water.

3d, That the principal sources of pollution of Fresh Pond itself can be diverted. The sewage discharging into the pond at Cushing Street, and that into Alewife Brook and Black's Nook, can be conducted away from the pond by means of sewers.

4th, That, in order to still further preserve the purity of

Fresh Pond, the city authorities should exercise constant supervision over Fresh-pond Hotel and its adjoining grounds, and the Fresh-pond meadows, and prevent upon this territory the carrying-on of any business or the erection of any buildings, the refuse from which would tend to injure in any way a source of water-supply. And if the city has not this power vested in its Board of Health, or other board, it should obtain it, if possible, by legislative enactment.

5th, That the water of Little Pond and Wellington Brook is at times polluted to so great an extent, and with material of so dangerous a character, that these waters are totally unfit to be used as sources of water-supply; and, since this pollution is of such a nature as to render it impossible to prevent it from entering these waters, their use should be discontinued, and they should be prevented from entering Fresh Pond.

6th, That some other additional supply should be obtained.

7th, That, if the above-mentioned sources of pollution of Fresh Pond be removed, the purity of its water may be sufficiently preserved, so as to render it suitable to be used as a source of water-supply for an indefinite period, and also as a storage reservoir, if necessary, for any other additional supply.

OBSERVATIONS ON FRESH POND, CAMBRIDGE.

BY

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OBSERVATIONS ON FRESH POND, CAMBRIDGE.

THE present paper is a contribution to our knowledge in the matter of stored surface-waters. The observations recorded form a part of an investigation now in progress into the question, How far is the circulation due to difference of temperature of practical importance in such ponds and reservoirs as are usually employed in this region for purposes of water-supply? The investigation was prompted by views advanced by an eminent authority with which the experience of the writer led him to disagree. It is not, however, proposed to enter into a full discussion of this question at this time, but simply to present the results of certain observations which may be of interest, as the pond on which the observations were made is actually used for water-supply.

Fresh Pond covers an area of some two hundred acres, and serves as the source of water-supply of Cambridge, Mass., lying, in fact, partly within the city limits. The pond is fed mainly by the ground-water or by actual springs. Many analyses of the water have been made in previous years.[1] The present samples were taken at the entrance to the bay from which the water is pumped (two and one-quarter million gallons per day on the average during 1878),[2] about at the point where the letter "P" of "Fresh Pond" falls in the map opposite p. 372 of the Ninth Annual Report of the State Board of Health. The water at this part of the pond is, as a rule, from thirty-five to forty feet deep. The samples were taken in sets of three, one as near the bottom as possible, one at twenty feet from the surface, and one at two feet from the surface. An attempt was made to determine the depth of color in the different samples, but the color was

[1] See Ninth Annual Report of State Board of Health, 1878, pp. 338, 339. Also Report of the Special Committee on the Water-Supply of the City of Cambridge, 1879, pp. 43-49.

[2] Fourteenth Annual Report of Cambridge Water Board, 1879, p. 34.

so faint that the attempt was abandoned. Observations on the temperature at these various depths, as well as the results of the partial chemical examination, are included in the following tables.

TABLE I. — *Examination of Fresh Pond, Mass. Water taken Two Feet below the Surface.*

[Results expressed in Parts in 100,000.]

Number.	DATE.	Height of Water in Pond.	Temperature in Degrees, Centigrade.	Ammonia.	"Albuminoid Ammonia."	Total Solid Residue dried at 100° C.	Chlorine.
	1878.						
1	May 4	16.40	16.5	0.002	0.018	12.4	1.41
4	" 14	–	14.5	0.003	0.015	13.1	1.23
7	June 4	16.11	19.	0.004	0.015	16.1	1.41
10	" 12	15.68	17.3	0.003	0.015	13.3	1.31
13	" 19	15.38	20.5	0.003	0.013	13.7	1.38
16	" 25	15.30	22.2	0.003	0.028	15.6	1.47
19	July 2	14.99	28.0	0.004	0.025	14.7	1.47
22	" 9	14.57	26.0	0.003	0.018	13.8	1.38
25	" 16	14.60	25.3	0.003	0.020	13.2	1.30
28	" 23	14.38	24.0	0.002	0.017	13.2	1.40
31	Aug. 6	14.25	24.0	0.004	0.020	11.7	1.44
34	" 13	14.75	24.0	0.004	0.022	12.0	1.37
37	" 20	14.67	24.0	0.004	0.019	11.0	1.36
40	" 27	14.54	22.3	0.002	0.020	11.7	1.31
43	Oct. 21	13.74	–	0.018	0.017	13.3	1.46
46	Nov. 7	13.66	9.5	0.031	0.017	11.5	1.22
49	Dec. 7	14.50	4.5	0.030	0.023	12.6	1.30
	1879.						
52	Jan. 2	14.78	0.5	0.017	0.017	12.3	1.38
55	" 14	14.68	0.7	0.017	0.014	12.4	1.28
58	" 22	14.58	0.9	0.018	0.016	11.8	1.40
61	April 14	15.16	6.0	0.007	0.014	12.8	1.61
64	May 13	15.46	18.5	0.003	0.016	13.0	1.46

TABLE II. — *Examination of Fresh Pond, Mass. Water taken about Twenty Feet below the Surface.*

[Results expressed in Parts in 100,000.]

Number.	Date.	Height of Water in Pond.	Temperature in Degrees, Centigrade.	Ammonia.	"Albuminoid Ammonia."	Total Solid Residue dried at 100° C.	Chlorine.
	1878.						
2	May 4	16.40	12.5	0.002	0.017	12.1	1.42
5	" 14	–	14.5	0.003	0.014	13.3	1.27
8	June 4	16.11	16.5	0.005	0.015	14.4	1.39
11	" 12	15.68	16.8	0.003	0.016	13.7	1.31
14	" 19	15.38	16.8	0.006	0.016	14.4	1.37
17	" 25	15.30	16.6	0.009	0.016	13.6	1.42
20	July 2	14.99	16.7	0.012	0.024	14.9	1.33
23	" 9	14.57	16.4	0.010	0.018	13.9	1.40
26	" 16	14.60	16.8	0.007	0.021	13.8	1.25
29	" 23	14.38	16.8	0.012	0.017	13.8	1.36
32	Aug. 6	14.25	17.3	0.005	0.019	13.5	1.39
35	" 13	14.75	20.1	0.006	0.020	12.6	1.36
38	" 20	14.67	20.0	0.004	0.018	12.5	1.36
41	" 27	14.54	20.0	0.002	0.020	13.4	1.29
44	Oct. 21	13.74	–	0.018	0.017	12.9	1.44
47	Nov. 7	13.66	9.2	0.035	0.019	11.5	1.24
50	Dec. 7	14.50	4.3	0.029	0.024	12.2	1.34
	1879.						
53	Jan. 2	14.78	1.0	0.017	0.016	12.0	1.38
56	" 14	14.68	1.3	0.016	0.014	12.2	1.30
59	" 22	14.58	2.0	0.018	0.013	12.0	1.40
62	April 14	15.16	5.0	0.004	0.013	12.6	1.62
65	May 13	15.46	13.0	0.003	0.016	13.0	1.44

TABLE III. — *Examination of Fresh Pond, Mass. Water taken about Thirty-five Feet below the Surface.*

[Results expressed in Parts in 100,000.]

Number.	Date.	Height of Water in Pond.	Temperature in Degrees, Centigrade.	Ammonia.	"Albuminoid Ammonia."	Total Solid Residue dried at 100° C.	Chlorine.
	1878.						
3	May 4 .	16.40	8.5	0.018	0.016	12.2	1.38
6	" 14 .	–	8.5	0.027	0.015	12.9	1.26
9	June 4 .	16.11	8.8	0.074	0.015	15.7	1.37
12	" 12 .	15.68	8.6	0.078	0.017	13.9	1.34
15	" 19 .	15.38	8.7	0.105	0.023	14.5	1.39
18	" 25 .	15.30	9.2	0.100	0.010	13.8	1.45
21	July 2 .	14.99	9.3	0.112	0.025	15.2	1.40
24	" 9 .	14.57	9.2	0.087	0.018	14.3	1.40
27	" 16 .	14.60	9.6	0.079	0.020	14.0	1.23
30	" 23 .	14.38	9.9	0.090	0.019	13.9	1.32
33	Aug. 6 .	14.25	10.1	0.068	0.021	13.3	1.35
36	" 13 .	14.75	10.0	0.095	0.021	13.9	1.42
39	" 20 .	14.67	10.2	0.129	0.018	13.6	1.34
42	" 27 .	14.54	10.0	0.099	0.023	14.2	1.37
45	Oct. 21 .	13.74	–	0.104	0.021	13.0	1.41
48	Nov. 7 .	13.66	8.7	0.037	0.019	11.9	1.22
51	Dec. 7 .	14.50	4.5	0.020	0.025	12.3	1.28
	1879.						
54	Jan. 2 .	14.78	1.0	0.018	0.015	12.3	1.36
57	" 14 .	14.68	1.7	0.018	0.014	12.2	1.30
60	" 22 .	14.58	1.8	0.019	0.013	11.9	1.40
63	April 14 .	15.18	4.4	0.004	0.008	12.6	1.60
66	May 13 .	15.46	8.3	0.020	0.015	12.9	1.50

Although the observations were not taken at regular intervals or with as great frequency as might be wished, they have been plotted in the form of curves, and are thus presented in the accompanying diagram.

The chemical examination included the determination of the ammonia, "albuminoid ammonia," the chlorine, and the total solids obtained by evaporating the water and drying the residue at 100° C. In the case of no one of the series of results is there a marked progressive change except in the "ammonia;" nor with this exception is there, as a general rule, any marked difference in the water taken from different depths.

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TABLE III. — E

Number.	DATE.
	1878.
3	May 4
6	" 14
9	June 4
12	" 12
15	" 19
18	" 25
21	July 2
24	" 9
27	" 16
30	" 23
33	Aug. 6
36	" 13
39	" 20
42	" 27
45	Oct. 21
48	Nov. 7
51	Dec. 7
	1879.
54	Jan. 2
57	" 14
60	" 22
63	April 14
66	May 13

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The results of the observations on temperature can be readily seen on the diagram, and little verbal description is necessary. It will be noticed that near the bottom of the pond the temperature is quite uniform from May to November, and drops rather suddenly to rise again in April. No measurements were made during February and March, on account of the ice, which prevented the use of boats, and did not allow safe passage on foot, so that it is impossible to say exactly when the observed rise of temperature begins. The surface-water is subject to much more variation, of course, and does indeed vary from day to day and at various hours of the same day; the water at twenty feet, which point was somewhat above the middle of the pond, had a tolerably uniform temperature during the early summer, becoming heated in August, and cooling thereafter.

If we compare together, as we are enabled to do by the curves in the diagram, the temperatures at the different depths observed at the same time, we see that during the eight months of the year, from April to November, the top-water is decidedly the warmer. Of course, with the difference in temperature, there is a difference in density; and if the pond were filled with pure water it is evident, that, in the absence of mechanically produced currents, the warmer water would remain on the top; with the difference of about fifteen degrees, which existed during July and August, the difference in density would be very considerable.[1] When the water begins to cool, the temperature falls throughout, and the cooling proceeds in such a way that the warmer and consequently the lighter water remains constantly at the top until November, after which and for some time the temperature is nearly uniform from top to bottom as far as I have observations. During the month of January, when the pond was covered with ice, the top water was somewhat cooler than the lower water; but still the top water is the lighter,

[1] The specific gravity of pure water at different temperatures has been determined by various observers with slightly different results. The following figures are those of Rossetti (*Annales de Chimie et de Physique*) [4], 17, p. 370.

0° = 0.999871	5° = 0.999990	10° = 0.999747
1° = 0.999928	6° = 0.999970	15° = 0.999160
2° = 0.999969	7° = 0.999933	20° = 0.998259
3° = 0.999991	8° = 0.999886	25° = 0.997120
4° = 1.000000	9° = 0.999824	

for the specific gravity of pure water at 2°, the bottom temperature, is 0.999969, and at 0.9°, the top temperature, is 0.999922. When the water begins to warm up in the spring after the ice has melted, the warming proceeds as the cooling did in the fall throughout the mass of the water, but in such a way that the upper water grows warmer and lighter more rapidly than that below.

In considering the water as pure water we shall not be led very far astray, because the determination of the total dissolved solids shows that, with a few exceptions noticed during the summer months, the water taken at the same time from the three depths does not show differences greater than the allowable error of analysis.

It should be here distinctly stated that the changes of temperature are certainly not the only causes which produce circulation in the water of a pond. Rain, wind, the continual entrance of ground-water into the pond, and the evaporation from the surface, the withdrawal of water for consumption or by natural channels, the unequal warming or cooling of the water in different portions of the pond, owing to differences in depth and to other circumstances, the constant moving-about of fish, the rising and falling of particles of suspended matter of nearly the same specific gravity as the water,[1] and many other causes, great and small, tend to mix the water and produce a uniform character. Considering, however, the effect of temperature alone, the pres ent observations indicate that the greatest mixing owing to actual differences of temperature would take place in the winter, and while the ice was forming or formed; but it is to be noticed, that, after the considerable differences of temperature which we obtain during the summer, there is a nearly uniform temperature by the 1st of November. During the summer the difference of temperature would tend to lessen the amount of circulation from other causes; and we might expect, that, if any marked perceptible change took place, it would be likely to be in the fall.

[1] It has been noticed that in ponds subject to the growth of algæ, such as the *Clathrocystis*, described in Dr. Farlow's paper, these plants generally fall to the bottom before the ice begins to form. If a period of warm weather occurs, even after the ice has acquired considerable thickness, the plants in a more or less decomposed condition rise up to the under surface of the ice, and when the ice increases in thickness become frozen in, rendering it in some instances unsalable.

If now we consider the chemical character of the water, we shall find that in one respect there is something worthy of note, and that is in regard to the amount of ammonia. The absolute amount is, in any case, small, and in the curve the variations are shown on a larger scale than in the case of the "total solids." It will be noticed that there is a much greater amount of ammonia in the bottom water during the summer, but that about Nov. 1 there is a sudden decrease, and there is at the same time an increase in the amount in the upper water. This increase cannot be due simply to the fact that the lower temperature of the water enables it to hold more ammonia, because the bottom water which goes on growing cooler contains a less amount of ammonia than it has during the summer when decomposition has been more active. The fact of the increase of ammonia in the autumn has been noticed by other observers, and explanations have been suggested. Thus Mr. S. P. Sharples, the chemist of the Cambridge Water Board, says,[1] —

"The amount of free ammonia in the [surface] water is small so long as plant-life is vigorous and healthy; but, so soon as this is checked by the frost in the fall, this [the ammonia] suddenly rises, from the fact that the plants commence to decay as soon as they are killed; and the amount of ammonia is also, no doubt, increased by the leaves that blow or fall into the pond, and there decay."

Professor E. S. Wood in a recent report[2] says, —

"The large increase in the amount of ammonia in the autumn may be explained in many ways. A portion may be due to decaying vegetation, but not the whole; since we do not observe so large an increase in other ponds which are subjected to the same conditions as Fresh Pond, so far as decaying vegetation is concerned. It may also be partly explained by the surface washings from the cultivated land, caused by heavy rains in the fall and spring, at which seasons the manure is applied to the land."

No doubt the general statements made by Dr. Wood are true; but the facts just noted offer another explanation of this well-marked increase of ammonia in the fall, — namely, that the very nearly uniform temperature which exists throughout the mass of the pond from about the 1st of

[1] Fourteenth Annual Report of Cambridge Water Board, 1878, p. 9.
[2] Report of the Special Committee on the Water Supply of the City of Cambridge, 1879, p. 50.

November, or somewhat earlier, gives the greatest opportunity for the mixing of the water on account of diffusion and other general causes, and at the same time slight differences of temperature caused by the cooling of the surface-water and by the alternations of cold and warm weather prior to the formation of the solid crust of ice will have very much more effect in producing currents than in summer when there is a considerable difference in temperature between the bottom and the top.

Owing to the slightly alkaline character of the water, the ammonia is probably all the while escaping as ammonia-gas or as carbonate of ammonia, and some is also being oxidized to nitrates; and, as a result, it would appear that, in the early spring, the amount is comparatively small throughout the mass of the water. As the temperature rises, the increase of decomposition causes an increase of ammonia; and as the tendency of the water to circulate becomes less and less, owing to the continually increasing difference of temperature and specific gravity, the ammonia accumulates in the bottom water.

In order to prove the truth of this theory, observations over a more extended period are necessary. We should not, of course, find exactly the same temperatures at corresponding times each year, but we should expect to discover the same general condition of things. Such observations as I have been able to make or have made since the period covered by the diagram are here presented, and do not disagree essentially with those of the previous year.

TABLE IV. — *Examination of Fresh Pond, Mass. Temperature and Ammonia at Different Depths.*

Date.	Depth from Surface.	Temperature in Degrees, Centigrade.	Ammonia in parts in 100,000.	
1879.				
July 16 . .	2 feet	27.2	–	
" 16 . .	20 "	17.0	–	
" 16 . .	35 "	11.0	–	
Aug. 19 . .	2 "	21.2	0.008	After a heavy rain.
" 19 . .	20 "	20.8	0.009	
" 19 . .	30 "	11.0	0.068	
Oct. 2 . .	2 "	18.8	0.004	
" 2 . .	20 "	16.3	0.005	
" 2 . .	31 "	10.0	0.016	
1880.				
Jan. 5 . .	2 "	2.0	0.029	Ice about 3 inches thick.
" 5 . .	20 "	2.3	–	
" 5 . .	34 "	2.7	0.036	
" 26 . .	2 "	2.8	0.028	Ice about 6 inches thick.
" 26 . .	18 "	3.0	0.027	
" 26 . .	30 "	3.2	0.029	

We notice a rather curious fact, — that the water taken through the ice in January, 1880, has been much warmer than it was in January, 1879. This may be explained because we have had this winter a great deal of warm and open weather, and the water which enters the pond is probably warmer. As last year, the water is slightly but unmistakably warmer at the bottom than at the top.

It may be well in this connection to correct the current statement of text-books on chemistry and physics, which state generally that in lakes and rivers "the temperature of the whole mass is reduced to 4° C., after which the surface-water never sinks, however much it may be cooled, as it is always lighter than the deeper water at 4°. Hence ice is formed only at the top, the mass of water retaining the temperature of 4°."[1] This statement is not true in the case of waters of

[1] This is quoted from the recently published Treatise on Chemistry, by Roscoe and Schorlemmer.

moderate depth, as shown by the formation and persistence of anchor-ice in ponds and streams. Moreover, the records of the United-States Signal Service show that at the points where observations are regularly made, the water is frequently of the temperature of 32° F. (0° C.) *from top to bottom* for several days before the surface is frozen over.[1] The observations here put on record show that even in ponds where the water is thirty-five feet deep, the temperature at the bottom may fall considerably below 4° C.; and I have found the same thing to be true in other ponds, where the depth is as much as seventy feet.

Remarks on Methods of Collection and Observation.

Collection of Samples. — The water was collected in glass bottles of two and one-half liters capacity, which were lowered to the required depth, and then opened by a cord attached to the stopper.

Observations of Temperature. — A centigrade thermometer was inserted in the bottle used for the collection of the water; and after the bottle had filled it was allowed to remain until there was certainty that the mass of the bottle and the thermometer had acquired the actual temperature of the water. The thermometers used were graduated to degrees, and the tenths were estimated; the error in reading could hardly in any case be greater than 0.2°, and as the thermometers were compared with standards and duly corrected, the total error would not be much greater than 0.2°. The curves of temperature on the diagram were plotted from the data of the table; of course they would be the same if Fahrenheit degrees were employed. For convenience it may be said, however, that

0° C. = 32° F.	15° C. = 59° F.
5° C. = 41° F.	20° C. = 68° F.
10° C. = 50° F.	25° C. = 77° F.

Since the observations recorded above were made, I have procured and am now using a Negretti and Zambra deep-sea thermometer which has been very accurately corrected. I have found, however, that the method described above gives

[1] These observations are made at lake and river stations near the shore, and seldom in water over fifteen feet in depth, and no observations are taken after ice has formed.

results which agree with those obtained with the deep-sea thermometer, and for shallow waters, with proper care, answers well enough.

Chemical Examination. — In a water like that of Fresh Pond, the "total solid residue" in two samples of water taken at the same time and from the same point would frequently differ by as much as 0.25 or perhaps even 0.5 part; so that it is only during June, July, and August that the observed differences in the samples at different depths are really to be considered essential. The determinations of chlorine were made by the usual volumetric method, and the results are plotted on a scale ten times as great as that employed in the case of the "total solids." Here again the difference between the water at different depths is in almost every instance within the allowed error of analysis. The ammonia and "albuminoid ammonia" are determined by the now well-known Wanklyn method. By ammonia is understood the amount obtained by distilling the water with carbonate of soda; and, by the "albuminoid ammonia," the amount which is given off by a subsequent distillation with an alkaline solution of permanganate of potash.

For aid in carrying on this investigation, I am indebted to my former assistants, Mr. Thomas F. Stimpson, S. B., now chemist of the Silver Spring Bleaching and Dyeing Company, Providence, R. I.; and Mr. John E. Hardman, S. B., now in charge of smelting-works at Red Cliff, Col.

ON THE EXAMINATION OF MYSTIC WATER.

WITH REMARKS ON

FRANKLAND'S METHOD OF WATER ANALYSIS.

BY

WM. RIPLEY NICHOLS,

PROFESSOR AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

ON THE EXAMINATION OF MYSTIC WATER.

WITH REMARKS ON

FRANKLAND'S METHOD OF WATER ANALYSIS

THIS paper presents in tabular form the results of the examinations of Mystic water, which have been made in the laboratory of the Massachusetts Institute of Technology during the past year. The samples have been furnished by Mr. Joseph P. Davis, city engineer; the water was drawn at the office of the Mystic Water Board in Charlestown. The analytical work has been done under my direction by my assistant, Mr. W. W. MacFarlane, S. B., and I have full confidence in the accuracy of the results.

The examinations were made mainly for the sake of obtaining a wider experience in the application to our New England waters of the method of analysis devised by Frankland and Armstrong, and employed by the Rivers Pollution Commission in the large number of analyses made in their investigations into the waters of Great Britain.

The table (Table I.) contains the results obtained by this method,— the "organic carbon" and "organic nitrogen,"— and also the results obtained by the more commonly employed method of Wanklyn, according to which the amount of nitrogenous organic matter is indicated by the "albuminoid ammonia." As Frankland's method has hitherto been seldom used in this country, and has not been employed by the State Board of Health, it will not be out of place to make some remarks with reference to the method itself, and the interpretation of the results obtained by means of it.

By this method a certain quantity of the water is evaporated to dryness with suitable precautions; the dry residue is then subjected to a process of organic analysis, and is burned in a closed vessel in such a manner as to convert all the

TABLE I. — *Examination of Mystic Water.*

[Results expressed as so many parts by weight in 100,000 parts by weight of the water.]

DATE.	Organic Carbon.	Organic Nitrogen.	Sum of Organic Elements.	Ratio. $\frac{\text{Carbon}}{\text{Nitrogen}}$	Ammonia.	"Albuminoid Ammonia."	Total Solids.	After Filtration through Paper.		
								Organic Carbon.	Organic Nitrogen.	Total Solids.
1879.										
June 19 . .	0.390	0.083	0.473	4.7	–	–	–	–	–	–
" 26 . .	0.395	0.088	0.483	4.5	–	–	–	–	–	–
July 3 . .	0.445	0.056	0.501	7.9	–	–	9.6	–	–	–
" 10 . .	0.762	0.100	0.862	7.6	–	–	10.0	0.436	0.077	–
" 17 . .	0.716	0.112	0.828	6.4	–	–	10.2	–	–	–
" 24 . .	–	–	–	–	0.004	0.033	10.5	0.381	0.043	9.7
" 31 . .	0.782	0.126	0.908	6.2	0.005	0.037	10.8	0.421	0.038	9.9
Aug. 7 . .	0.727	0.082	0.809	8.9	0.004	0.033	–	–	–	–
" 14 . .	0.483	0.065	0.548	7.4	0.004	0.024	10.2	0.378	0.040	9.7
" 21 . .	0.400	0.107	0.507	3.7	0.005	0.024	10.4	0.367	0.099	10.1
" 28 . .	0.455	0.100	0.555	4.5	0.005	0.023	10.7	–	–	10.4

Sept. 4 . .	–	–	–	–	0.003	0.019	9.8	0.389	0.064	9.6
" 11 . .	0.407	0.112	0.519	3.6	0.004	0.021	9.5	–	–	–
" 18 . .	0.330	0.081	0.411	4.1	0.002	0.020	9.7	–	–	–
" 25 . .	0.352	0.062	0.414	5.7	0.004	0.020	9.6	–	–	–
Oct. 2 . .	0.364	0.059	0.423	6.2	0.004	0.016	9.8	–	–	–
" 9 . .	0.328	0.022	0.350	14.5	0.007	0.015	10.1	–	–	–
" 16 . .	0.315	0.021	0.336	15.0	0.001	0.013	9.6	–	–	–
" 23 . .	0.316	0.055	0.371	5.7	0.003	0.013	9.7	–	–	–
" 30 . .	0.323	0.063	0.386	5.1	–	–	–	–	–	–
Nov. 7 . .	0.301	0.056	0.357	5.4	0.005	0.013	10.0	–	–	–
" 20 . .	0.374	0.056	0.430	6.6	0.005	0.009	9.5	–	–	–
Dec. 4 . .	0.275	0.022	0.297	12.5	0.009	0.011	9.9	–	–	–
1880.										
Jan. 1 . .	0.315	0.046	0.361	6.8	0.012	0.013	9.9	–	–	–
" 15 . .	0.313	0.054	0.367	5.8	0.012	0.011	10.2	–	–	–
Average . .	0.429	0.070	0.499	6.1	0.005	0.019	10.0	–	–	–

carbon and *nitrogen* of the organic matter into gaseous substances, which are collected and measured. The carbon and nitrogen are spoken of as *organic carbon* and *organic nitrogen* respectively, and they are sometimes taken together and spoken of as the *organic elements*. The method is difficult and tedious, requiring the use of expensive and frangible apparatus, and consuming considerable time: for these reasons it can never be popular. Moreover, as is the case with every method employed for obtaining indications of the amount and character of the organic matter in a water, the results must be interpreted by a knowledge of the source from which the water is derived, and of its surroundings. It must also be borne in mind, that the sum of the amounts of organic carbon and organic nitrogen does not represent the actual *amount of organic matter* present, for most organic substances which occur in natural waters contain in addition a larger or smaller amount of oxygen and of hydrogen; how much, in any particular case, we cannot tell. In interpreting the results, it is felt that great importance attaches to the relative proportion of carbon to nitrogen; for it is, in general, true that organic matter of vegetable origin contains a larger proportion of carbon, while organic matter of animal origin contains a larger proportion of nitrogen. This statement, however, cannot be taken without some qualification, as will appear farther on.

In studying the figures in the foregoing table we see very clearly one fact to which I have frequently called attention; namely, the great variation to which surface-waters are subject, and especially in respect to the organic matter which they contain. On this account it is seldom possible to form a just idea of the general character of such a water from a single examination. This variation is rendered very large in the present instance, because during the summer there was in Mystic Pond, and in the water as drawn in the city, a very large amount of the microscopic algæ, which will be more particularly described by Dr. Farlow in subsequent pages.

In order that the effect of their presence may appear more clearly, I have prepared the following table (Table II.), in which we have the results presented, first in monthly averages, and then in averages for certain periods into which

there seemed to be a natural division. The algæ became numerous enough to awaken complaint and apprehension after the middle of July, and the trouble was at its height in the latter part of July and during August. For convenience I have put into the same table the results of the "albuminoid ammonia" determinations, to which reference will be made later.

TABLE II. — *Examination of Mystic Water.*

[Results expressed as so many parts by weight in 100,000 parts by weight of the water.]

DATE.	No. of Samples.	Sum of the Organic Elements.	"Albuminoid Ammonia."
1879.			
June. . . .	Average of 2 samples	0.478	–
July	" " 4 "	0.775	0.035[1]
August . . .	" " 4 "	0.605	0.026
September . .	" " 3 "	0.448	0.020
October . . .	" " 5 "	0.333	0.014
November . .	" " 2 "	0.393	0.011
December . . .	" " 1 "	0.297	0.011
1880.			
January . . .	" " 2 "	0.364	0.012
June 19 to July 3 .	" " 3 "	0.486	–
July 10 to Aug. 7 .	" " 4 "	0.852	0.034
Aug. 14 to Sept. 11 .	" " 4 "	0.526	0.022
Sept. 18 to Jan. 15 .	" " 12 "	0.375	0.014

Even in the absence of any abnormal condition such as was caused this summer by the growth of algæ, there is at times a considerable variation in the amount and character of the organic matter in the water, as for instance, in October, 1879, when on the 9th and 16th of the month the nitrogen was very much below the usual amount, as again on Dec. 4. That such changes should take place, is not at all surprising, although we may not be able to explain the reason why in each particular case. The water is taken from near the surface of the pond, flows in a conduit for some distance to the pumping-station, is pumped into an open reservoir, and thence distributed into the city. We

[1] Average of two samples.

know that the organic matter in natural water undergoes change with greater or less rapidity owing to the differences of temperature, to the action of the wind, to the length of time during which the water is exposed to the sun and air in the reservoir, and to other such causes.

That the considerable variation in the amount and relative proportion of the organic carbon and organic nitrogen is not peculiar to Mystic water, may be seen from the Tables III. and IV.

TABLE III. — *Examination of Glasgow Water by* PROFESSOR BISCHOF.

[Results expressed as so many parts by weight in 100,000 parts by weight of the water.]

DATE.	Organic Carbon.	Organic Nitrogen.	Ratio. $\frac{\text{Carbon}}{\text{Nitrogen}}$	Sum of Organic Elements.
1873.				
May 12	0.204	0.017	12.0	0.221
June 16	0.181	0.016	11.3	0.197
July 18	0.192	0.008	[24.0]	0.200
Aug. 1	0.209	0.011	19.0	0.220
Sept. 1	0.156	0.047	3.3	0.203
Oct. 14	0.256	0.028	8.2	0.284
Nov. 24	0.177	0.035	5.1	0.212
1874.				
Jan. 15	0.154	0.021	7.3	0.175
Feb. 5	0.251	0.008	[31.4]	0.259
March 10	0.185	0.007	[26.4]	0.192
April 1	0.169	0.003	[56.3]	0.172
May 5	0.235	0.011	[21.3]	0.246
Average . . .	0.197	0.018	10.9	0.215

Table III. contains the results of monthly examinations of the water of Glasgow, Scotland, as reported by Professor Gustav Bischof of the Andersonian University. The water comes from an unpolluted Highland lake, Loch Katrine, and flows some thirty-six miles in a masonry conduit. Table IV., which, like No. III., is compiled from the Sixth Report of the Rivers Pollution Commission, shows the variation in the water of the several companies which supply London with filtered river-water. These are not *monthly averages*, but the results of the examination of single samples taken at monthly intervals.

TABLE IV. — *Variation in Monthly Samples of London Water, 1873.*

NAME OF COMPANY.	ORGANIC CARBON.			ORGANIC NITROGEN.		
	Maximum at any one time.	Minimum at any one time.	Mean of 12 Samples.	Maximum at any one time.	Minimum at any one time.	Mean of 12 Samples.
Chelsea . .	0.447	0.121	0.197	0.067	0.013	0.034
West Middlesex,	0.341	0.114	0.173	0.055	0 015	0 028
Southwark .	0.396	0.118	0.186	0.060	0.020	0.030
Grand Junction,	0.412	0.117	0.183	0.050	0.016	0.032
Lambeth . .	0.449	0.130	0.206	0.065	0.021	0.040
New River .	0.257	0.059	0.107	0.032	0.010	0.018
East London .	0.333	0.109	0.175	0.082	0.015	0.035

In order to judge of the general character of the Mystic water, as shown by the results of Frankland's method of analysis, we have the necessary material in Table V., from which it appears that the total amount of organic matter as indicated by the organic carbon and nitrogen would be somewhat less than in Cochituate, were it not for the increase brought about by the development during the summer months of the algæ, to which allusion has been made. It appears, however, that, on the whole, there is a *larger proportion* of nitrogen in the Mystic than in the Cochituate water, and this agrees with what we know of the character of the respective water-sheds. Considering also that the total dissolved substances, organic and inorganic, amount to twice as much in the Mystic as in the Cochituate supply, we must regard the latter as the better water; the examination shows, however, as far as chemical examination can show, that, in spite of the polluting influences which have been at work in the ponds and streams supplying Mystic Pond, the water in its normal condition is still good, and well suited for domestic supply.

Although considerable importance is attached to the relation of carbon to nitrogen as indicating the character of the organic matter, too much stress cannot be laid upon this ratio. Frankland found that, in waters rendered impure by the presence of peaty matter, the average amount of carbon was to the amount of nitrogen as 11.9 : 1, while the proportion in sewage was as 1.8 : 1. Frankland found, however, that the influence of oxidation on peaty matter, i.e., vegeta-

TABLE V. — *Comparison of Mystic with Other Waters.*

[Results expressed in Parts in 100,000.]

DATE.	DESCRIPTION.	Organic Carbon.	Organic Nitrogen.	Ratio. Carbon / Nitrogen
June, 1879, to Jan. 1880.	Mystic water. Average of 23 samples . .	0.429	0.070	6.1
Sept. 18, 1879, to Jan. 15, 1880.	Mystic water. Average of 12 samples [1] . .	0.325	0.050	6.5
Jan. to June, 1879.	Boston water (Cochituate Lake and Sudbury River). Average of 22 samples [2] . . .	0.408	0.052	7.9
June, 1879, to Jan. 1880.	Boston water. Average of 24 samples [3] . .	0.424	0.048	8.8
Jan. to June, 1879.	Fresh Pond, Cambridge. Average of 11 samples [4]	0.417	0.074	5.6
May, 1873, to May, 1874.	Glasgow water. Average of 12 samples [5] . .	0.197	0.018	10.9
	Unpolluted upland surface water. Average of 195 samples [6] . .	0.322	0.032	10.0

ble matter containing a considerable proportion of carbon, is to decrease the amount of carbon, while by the oxidation of animal matter, i.e., matter containing a considerable proportion of nitrogen, it is the nitrogen which decreases most rapidly. "It is thus evident that the proportions of nitrogen to carbon in soluble vegetable and animal organic matters *vary in opposite directions during oxidation*, — a fact which renders more difficult the decision as to whether the organic matter present in any given sample of water is of animal or vegetable origin."

It is not impossible that the smaller ratio observed in the cases of Mystic Lake and Fresh Pond may be due in part to the fact that a larger proportion of the water comes in through the bottom and sides of the pond, and the water thus entering contains a smaller relative amount of nitrogen.

[1] These are the samples taken after the algæ became less abundant. They are included also in the previous twenty-three.

[2] Third Annual Report of the Boston Water Board, 1879, p. 35.

[3] From unpublished results.

[4] These samples were taken from the pond itself at various depths, and do not claim to represent the average character of the water as delivered in Cambridge, Mass.

[5] Sixth Report of Rivers Pollution Commission, p. 347. Already quoted in Table III.

[6] Sixth Report of Rivers Pollution Commission, p. 425.

It is to be said, however, that while Fresh Pond is supplied in great measure from underground sources, the bulk of the water entering Mystic Lake comes from the Abajonna River, and it is said that the rainfall affects the Mystic basin more rapidly than that of Lake Cochituate.

On the whole, I believe that the ratio obtained from the average of a considerable number of determinations gives a valuable means of judging of a *surface* water; in the case, however, of well-waters or of ground-waters generally, where the amount of organic matter is very small, I have been led by a study of the results of the Rivers Pollution Commission, and from the somewhat limited number of analyses that I have myself accumulated, to the conclusion that we cannot attach any weight to the ratio of carbon to nitrogen, but must form our judgment from the "sum of the organic elements." For the same reason I have bracketed certain figures in Table III., lest they should be thought to mean more than they do. It is evident that a very small error in the amount of nitrogen would make an appreciable difference in the ratio. An error of 0.005 part in the nitrogen is the allowed limit, although duplicate determinations usually agree closer than this, and frequently they agree exactly as far as the third place of decimals. The carbon should agree, in duplicate determinations, to the second place.

Finally, I have put into Table VI. the average of the ammonia and "albuminoid ammonia" determinations on the Mystic and several other waters.

TABLE VI. — *Comparison of Mystic with Other Waters.*

DATE.	Description.	Ammonia.	"Albuminoid Ammonia."
July, 1879, to Jan. 1880.	Mystic water. Average of 19 samples	0.005	0.019
Sept. 1879, to Jan. 1880.	Mystic water. Average of 11 samples[1]	0.006	0.014
July, 1877, to Apr. 1879.	Boston water. Average of 40 samples	0.004	0.015
May, 1878, to May, 1879.	Fresh Pond, surface water. Average of 22 samples .	0.008	0.017

[1] These are the samples taken after the algæ became less abundant. They are included also in the previous nineteen.

In Table II. we notice that in the lower group of averages the amounts of "albuminoid ammonia" bear the same relation to each other as the amounts of the "organic elements." This is purely accidental; and a study of Table I., or even of the monthly averages in Table II., will show that there is no coincidence or uniformity of relation. If both methods are equally accurate, this shows that in addition to the organic matter which furnishes the "albuminoid ammonia," there is always other nitrogenous matter in variable quantity.

It may be said that while as a chemical method that of Frankland is superior to that of Wanklyn, and while it is more satisfactory in following out the changes of surface-waters, as a rule, — for practical purposes, — the Wanklyn method suffices, provided the results are interpreted with a proper knowledge of the history of the water under examination, and Frankland's method does not dispense with the necessity for such knowledge.

ALGÆ OBSERVED IN STORAGE-BASIN No. 3 OF THE BOSTON WATER SUPPLY, IN 1879.

BY

A. FTELEY, C.E.,

RESIDENT ENGINEER BOSTON WATER WORKS.

ALGÆ IN A WATER-SUPPLY.

THE causes of the alterations observed, principally during the summer, in the quality of the water of our public supplies, remain very often unknown, and local observations are generally found to be insufficient. A complete system of observations extending over several years, covering an extensive territory, and embracing various descriptions of water-supplies, would be needed to throw any light on the question.

The following observations have been limited to some of the ponds connected with the water-supply of Boston. They cover too short a time to be conclusive, but they have furnished a few facts which may suggest some new and more complete researches.

Of the three sources of water-supplies of Boston, one, the Cochituate, has presented no unusual feature this year. The new supply from Sudbury River was in a peculiar condition. Although its water has been furnished in a large proportion to the city for the last five years, the new reservoirs were filled this year for the first time. Notwithstanding these unfavorable conditions, the water has been unobjectionable in quality; but it has been observed that sulphuretted hydrogen was found in the reservoirs during July and August, and could be plainly perceived when the water was flowing through the sluice-gates. The smell of the gas disappeared after a short exposure of the water to the air, and none of it was ever detected in the conduit.

The temperature of the water in the reservoirs at the time that the presence of sulphuretted hydrogen was detected in it was remarkably high, as shown by the accompanying diagram; and it was identical at top and bottom, although the depth at the point of observation was more than twenty feet: a number of readings taken in June, July, and August, but not noted at the time, showed a similar result, which

may suggest the idea that the temperature of the water was kept uniformly high by chemical action. The disengagement of sulphuretted hydrogen ceased apparently towards the end of August; but it may be seen by the diagram, that, since that time, the temperatures at top and bottom of reservoir No. 3 have continued to be singularly near one another.

The principal trouble experienced this summer about the water-supply of Boston was due to the presence of an abundant formation of algæ in some of the ponds of the Mystic supply, and also, to a less extent, in one of the new reservoirs on Sudbury River (Basin No. 3).

These minute plants, which appear to be uniformly distributed throughout the water, flow with it, and are of such a small bulk that they cannot be separated by screens; the wind has a noticeable effect on them, and often blows them towards the lee shore, where they accumulate, and form a solid green scum of a sharp green color. When in the fresh state they emit a peculiar musty odor; if stranded by the action of the wind, they soon decay, and form a bluish-green mass which develops a smell as of organic matter in process of decomposition; when in the water the algæ remain suspended for some time, and, after a while, sink to the bottom. This result, which it would be difficult to observe directly in a large mass of water, is indicated by the fact that the large quantities of algæ which have been found in the reservoir, at a time when there was no outflow from it, have diminished several times, and ultimately disappeared, without leaving at the surface or on the shores any indication of their presence. The same result has been obtained several times by putting in a closed bottle water containing some of the green scum collected in reservoir No. 3: after a short time, one or two days, a portion of the green matter, of a light shade, sinks to the bottom; examined under the microscope it proves to be composed of one kind only of algæ, presenting the appearance of strings of single cells; the rest, of a darker green, containing plants of a rounded shape, floats on the surface for a few days, and then sinks; before the end of one week all the vegetable matter is at the bottom, where its color changes from day to day from green to brown. Almost from the beginning of the experiment, the contents of the bottle emit an extremely offensive odor of decomposition,

which increases as the plants decay and lose gradually their characteristic form.

Of the formation of the algæ, or of its cause, little is known; but it is remarkable that they appear suddenly in large quantities. Shallow flowage, it is said, favors their development, probably on account of the higher temperature which the water attains in such conditions when heated by the sun. But they are formed very rapidly also in deep water: I have observed several times that large quantities of algæ appeared in a very short time, equally distributed through hundreds of millions of gallons of water twenty feet deep, several hundred feet from any shore, and in very calm weather: the quantity of algæ in the water, as observed in Basin No. 3, seemed to vary constantly, increasing or diminishing with wonderful rapidity.

I have some reasons to believe, from the statements of various persons, that the same kind of vegetation has been observed in years past in this vicinity; but, in the absence of reliable evidence on the subject, some doubt may exist about the identity of the vegetable formation.

It has been suggested that the development of the algæ in the Mystic supply may have been favored, if not caused, by the presence of the sewage-matter which finds its way into it; but the algæ have been observed also, in less quantity however, in ponds which are entirely free from such pollutions. It is particularly remarkable that no vegetable growth of the same kind has been seen in the Abajonna River or its mill-ponds, although they receive some very objectionable drainage, at the time that the other branch of the Mystic supply, the Horn Pond branch, has been full of it: this fact is so much more noticeable, because Horn Pond, where the algæ have been found in great abundance, is very deep generally, and presents a small proportion of shallow flowage. A somewhat similar condition of things has been observed in Framingham, where algæ have been growing in Basin No. 3, a deep artificial reservoir built on the Stony Brook branch of Sudbury River; while Basin No. 2, on the other branch of the river, and of less depth, has been entirely free from vegetable growth.

The accompanying diagram shows simultaneous observations made in October, November, and December. It does

not seem that the degree of humidity of the atmosphere, or the barometric pressure, has any marked effect on the algæ; but their formation appears to follow the temperature, principally the temperature of the water, increasing and diminishing with it. The scale for the diagram showing the amount of algæ found in the water indicates only proportional quantities obtained by daily observations. To determine these quantities, the water was examined at certain given stations, each representing a portion of the total area, and samples procured at each station, at top, middle, and bottom of the water, were compared to a constant standard: co-efficients proportional to the areas represented by each station, and to the degree of turbidity of each sample as appreciated by the eye, were then used to establish the daily returns. These results may not be strictly correct, but it is believed that they represent very fairly the condition of the water.

Although screens fail to free the water from the algæ, the latter can be retained on filter-beds constructed in the usual manner: when they are abundant, however, they form in a short time an almost impervious covering over the filtering surfaces. To filter large quantities of water in these conditions, would require very extensive filtering-areas and frequent cleanings at a great expense.

A small experimental filter, one yard square, made of gravel and sand, and constructed in the well-known manner recommended for water-supplies, showed, that, in operating on water containing a moderate quantity of algæ, the filtering capacity of the apparatus was reduced in eight days from sixty gallons per twenty-four hours and per square foot to seventeen gallons; another time it was reduced in the same number of days from seventy-five to fourteen gallons.

The sand used being rather too fine, the filter was made over again with well-washed sand, from which all fine particles had been excluded by using a wire sieve of twenty-four meshes to the inch: in this case the filtering capacity was reduced in eleven days from one hundred and nine to twenty-three gallons per square foot and per twenty-four hours. The following table shows the daily results of the experiments.

Number of Gallons per Square Foot and per 24 Hours.

	First Experiment.	Second Experiment.	Third Experiment.
	Gallons.	Gallons.	Gallons.
First day . . .	60	75.1	109
Second day . . .	50	19.2	109
Third day . . .	53.3	18.5	120
Fourth day . . .	40	17	80
Fifth day . . .	19.17	16	80
Sixth day . . .	18.50	15.5	65
Seventh day . . .	16	15.5	53
Eighth day . . .	17	14.1	42.8
Ninth day . . .	–	–	34.3
Tenth day . .	–	–	26.6
Eleventh day . .	–	–	22.8

At the rate of the last experiment it would require two hundred and thirty-three thousand square feet of filtering-surface, at a cost of nearly half a million of dollars, including the plant for lifting the water to the filter-beds, and with grounds favorably disposed, to filter ten million gallons per day; each filter-bed would need cleaning once a week, and it would cost about twenty thousand dollars per year to maintain the works.

After each experiment, there was found on the surface of the filter a slimy, greenish matter, presenting the peculiar musty odor of the algæ; and the surface, when dry, became so much hardened by its mixture with the sediment, that, to the touch, it closely resembled slightly frozen sand. The sand did not appear to be penetrated by the vegetable deposit; a slight scraping of its surface showed it very free from foreign matter.

In the water thus filtered, no vegetable matter was detected; several gallons of it left for two months in a shallow tank half filled with loam did not show any vegetable growth: it has been observed also that some small shallow ponds formed by water gathered from the contaminated reservoir by filtration through a natural bank of gravel and sand were, during the summer, free from the same species of algæ.

As it is a matter of record that vegetable growths have been developed in filtered waters, whether they are of new

formation or reproduced by minute organisms which sand filters fail to retain, it must be remembered that the experiments above described were made in September and October, — too late in the year, perhaps, to be conclusive in that respect.

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ON SOME IMPURITIES OF DRINKING-WATER CAUSED BY VEGETABLE GROWTHS.

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ON SOME IMPURITIES OF DRINKING-WATER CAUSED BY VEGETABLE GROWTHS.

THE object of the present paper is to present in a popular form a statement of what is known with regard to the effect of the growth of different plants upon the water in the ponds, streams, and basins which supply the cities and towns of the Commonwealth. In this connection the subject will be discussed from a botanical point of view; and we can only consider certain striking properties, such as smell and taste, with relation to the particular species of plants which produce them, without taking into account the more subtile changes which can only be detected by chemical analysis. It is desirable that all who, in any sense, have charge of the public health, should have some familiarity with the common forms of plants likely to pollute drinking-water; because, as the matter now stands, the public are at the mercy of any person, who, armed with a compound microscope and a supply of Latin and Greek names, chooses to alarm the neighborhood by the announcement of the appearance in the water-supplies of plants whose injurious nature is supposed to be in direct proportion to the length and incomprehensibility of their names. The public are now beginning to read about the germ-theory of disease; and hearing that fevers may be produced by germs, and being told that germs are found in water, they very naturally but illogically infer that any small bodies found in the water are the germs of disease. Whatever of truth there may be in the germ-theory of disease, there is no doubt that designing persons impose on the credulity and fears of the public by representing as germs of disease microscopic plants which could not possibly have caused any of the diseases which have been supposed by scientific men to be produced by germs of a vegetable nature.

The most striking plants which are found in fresh water are those which are commonly called weeds; as, for example, pond-weed, pickerel-weed, eel-grass, &c. They all have distinct stems and leaves, and produce flowers, using the word in a botanical sense. In some cases, as in the pickerel-weed and pond-lilies, the flowers are striking, and readily recognized as such; but in most of the water-weeds they are small and obscure, and pass unrecognized by the public. The mass of the water-weeds of this region belong to a comparatively few botanical genera; e.g., *Myriophyllum*, *Ceratophyllum*, *Callitriche*, *Utricularia*, *Anacharis*, *Potamogeton*, *Naias*, *Vallisneria*, &c. They all start from roots at the bottom of ponds and streams, and may attain a length of several feet. Late in the season, and especially when the water has been disturbed by strong winds, they break from their attachments, and are washed ashore often in large heaps.

The *Lemnæ*, or duck-meats as they are popularly called (*Vide* Plate I., Figs. 4, 5), although clasesd by botanists with flowering-plants, differ in habit from our other common water-weeds. Instead of growing from the bottom, and having stems and leaves, they float in immense numbers on the surface of the water, forming a scum, as may be seen in the ponds of the town of Winchester, and at other points in the Mystic Valley. The duck-meats have no distinct stem and leaves, but consist merely of more or less roundish, grass-green disks, not usually more than a quarter of an inch in diameter, from the under side of which delicate roots project into the water. All the flowering plants commonly included under the name of water-weeds, whether they grow from the bottom, as is usually the case, and have distinct stems and leaves, or, as in the exceptional case of the duck-meats, float on the surface in the form of a scum, may, under ordinary circumstances, be considered harmless as far as any direct effect produced on drinking-water is concerned.

They may, however, be sources of trouble in two ways. In the first place, they may cause a mechanical difficulty, when growing luxuriantly, by choking up small streams or bodies of shallow water. This difficulty is not so likely to arise in bodies of water used as water-supplies as in the small sheets of water used for ornamental purposes. In the latter case, it not unfrequently happens that the means taken for

avoiding a growth of plants, such as cementing or stoning the bottoms and margins of small ponds, seem to encourage the growth of certain species of weeds which do not flourish to any very great extent in natural basins. In an artificial pond supplied by a brook in the neighborhood of Boston, the water was completely filled, and the pond disfigured, by a growth of the common water-starwort, *Callitriche verna*, which in this region rarely grows in large quantities in brooks. We may here refer to the well-known case of the plant known in England as Babington's curse, because it was introduced into that country from America by Professor C. C. Babington of Cambridge University. It is the species known to American botanists under the name of *Anacharis Canadensis*, which, although not at all rare in this country, is not so common as to prove a nuisance, or at least has not been so until within a comparatively few years. Introduced into England, and thence transferred to the Continent, it grew so luxuriantly as to choke small water-courses, and thus became a great pest. Even in this country, the species is becoming more common, and that, too, in places where special efforts are made to keep the water clear of weeds. We may instance as an example Fresh Pond, now used as a source of water-supply for the city of Cambridge, in which the *Anacharis* has become so abundant that the pond has to be periodically dredged. Just why certain species increase in bodies of water which have been artificially stoned or embanked, is not clear. It may be, that, by removing the larger weeds, a better chance is given to the smaller species, among which *Anacharis* is included. It may also be true in the case of small pieces of water, that the lime or other ingredients of the stones and cement used may make the water better adapted to the growth of some species at the expense of others.

A second source of danger from the presence of large masses of weeds, especially in basins liable to frequent changes in the height of the water-level, lies in the fact that they may serve as places of attachment or shelter for some of the injurious small plants to which we shall have occasion to refer presently.

We have said, that, under ordinary circumstances, no direct trouble is likely to arise from the growth of any of

the larger weeds in our water-supplies. By the expression, "under ordinary circumstances," we mean to presuppose that the plants are living and flourishing. The question still arises as to the effect they would produce in decay. The answer to this question falls rather within the province of a chemist than that of a botanist; but it is safe to say that no danger is to be anticipated from the death of vegetation in the autumn, certainly provided the water for immediate use is stored for a time in a receiving-reservoir.

The case of masses of plants suddenly killed by the lowering of the water in the heat of summer may be different. Here it is possible that trouble might arise; but we have no direct evidence to show that decided injury has resulted in any particular case from drinking water coming from ponds or streams in which were decaying plants of the group which we have characterized as weeds. Neither can we say that any well-defined odor or taste marks the water containing merely weeds in a state of decomposition. As we shall see, the extremely disagreeable tastes and odors are produced by plants which cannot be included in the group which we are now considering, — plants of a very different appearance and structure.

We have hitherto only considered the effect produced on the water by the growth and death of the comparatively large plants which we call weeds. Let us pass to an examination of the smaller but vastly more numerous plants belonging to the algæ, or that division of the flowerless plants which grow in the water or in wet places. Some of the species occur in the form of filaments, which have at times a length of several inches, or rarely a few feet; others form slimy masses of indefinite extent; and others still consist of single cells floating in the water, and generally invisible to the naked eye unless they occur in large numbers. Whatever their shape may be, we may, in considering the effect which they produce, divide the algæ into two groups: those which are grass-green or yellowish-green, and those which are bluish-green or purplish. To the group of grass-green algæ belong a large number of species which abound in our waters, and which look to the naked eye like fine threads. Some are more or less rigid, but the majority collapse when removed from the water. When examined with the micro-

scope, each filament is seen to consist of a series of cells placed end to end. In some species the filaments branch, but the majority do not.

Botanically considered, the grass-green filamentous species belong to three different orders, — the *Zoösporeæ*, the *Œdogonieæ*, and the *Conjugateæ;* and besides these there are a few filamentous *Desmideæ.* Compared with the others, the *Œdogonieæ* are small in size, and do not form masses of any considerable size; and we may say that, practically speaking, the bulk of our larger filamentous water-plants belong either to the *Zoösporeæ* or the *Conjugateæ.* The names are mentioned principally because of the different modes of reproduction found in the different groups. For a general view of the appearance of these plants as seen under the microscope, the reader is referred to Plate I., Figs. 6 and 7.

The plants belonging to the two groups last mentioned frequent rather shallow places, and grow attached to sticks and stones at the bottom or to the larger weeds. They often grow to the surface, where they form entangled masses several feet in extent. This is especially the case with the *Conjugateæ,* which form fleecy masses on the surface, which are not unfrequently frothy from the bubbles of air amongst the filaments. Neither of the groups mentioned is at all abundant in very deep water; but they are always found along the edges of our water-supplies, even when the banks have been covered by stone-work. In shallow bodies of water, like Fresh Pond and Horn Pond, they cover the bottom in some places.

The *Zoösporeæ* derive their name from their mode of reproduction, which is by means of small motile bodies, called zoöspores. The contents of each cell of the plant divide into a number of small green bodies, which escape into the water by an opening in the cell wall. These bodies, called zoöspores, swim about in the water for a short time by means of two, or in some cases four, vibratile threads, which are placed at one end. After a while the threads disappear, and the zoöspores come to rest. They then sink to the bottom, or become attached to different weeds growing in the water, and, in a short period, grow into filaments like those from which they came. In some cases the zoöspores unite in pairs. The details of the production, growth, and union

of zoöspores are curious, but need not be described here, as one can easily find an account of them in recent botanical text-books. We have mentioned briefly the zoöspores for the sake of showing with what rapidity these plants may increase under favorable circumstances, each cell of the filament being capable of forming a large number of zoöspores, each one of which may produce a new filament.

The reproduction of the *Conjugateæ* is somewhat different. In some of the cells oval bodies are produced, called, technically, zygospores (Plate I., Fig. 7, *s*). The latter are much larger than the zoöspores, and do not generally germinate and form new filaments until after a longer or shorter period of repose. The *Conjugateæ* generally produce their zygospores in spring and early summer, at which period they lose their bright green color, and become brownish.

Considered from a sanitary point of view, we may say that the grass-green algæ have no injurious effect upon the water in which they grow. On the contrary, we may regard their presence as an indication of its purity, for they do not grow in impure water. If almost any river or pond water, no matter how clear it appears, is placed in a covered glass jar, in a few days or weeks there will be formed a greenish expansion on the sides and at the bottom, which, on examination, will be found to consist principally of the young stages of development of some of the algæ which we have already described.

The algæ in question may, however, be so luxuriant as to fill up small bodies of water; and at Fresh Pond one sees large masses of them which have been removed with the *Anacharis* and other weeds. In shallow water used for ornamental purposes, as in the pond in the Public Garden in Boston, they sometimes abound to such an extent towards the end of summer as to be a nuisance. We have already pointed out the reason for their rapid increase in the fact that they reproduce by means of zoöspores. The species commonly found in this region are, in the majority of cases, the same as those found in Europe, and, in fact, in nearly all temperate regions. Some species are peculiar to this country, but they do not differ in their effect upon the water from the rest of the group. The determination of the species is rather a difficult matter, and purely technical; so that we need

not discuss the subject here, except to say that most of the species belong to what used to be called the genus *Conferva*, a name still retained by some writers on sanitary subjects.

Our commonest *Zoösporeæ* are *Cladophora glomerata*, *Rhizoclonium lacustre*, *Microspora floccosa*, &c., and our larger *Conjugateæ* belong principally to the very common genera *Spirogyra* and *Zygnema*. All the forms mentioned are perfectly harmless; yet, no longer ago than last October, one of the Boston papers gave an account of the dangerous condition of the pond in the Public Garden, saying that it was full of what was rather extraordinarily described as "the sewer fungus." An examination of the pond showed only species of *Cladophora* and *Zygnema*, both entirely harmless.

In passing we must mention the *Desmids* and *Diatomes*, small unicellular plants found floating freely in the water, or at times united in filaments of small size. The *Desmids* are grass-green; and the *Diatomes* yellowish-brown, and the cell-wall of the latter is silicious. Both consist of cells divided more or less regularly into two symmetrical halves; and, especially in the case of the *Diatomes*, the walls are covered with beautiful markings. Although interesting to botanists, they may here be neglected as having absolutely no injurious effect on the water.

We may also mention the species of *Characeæ* (Plate I., Figs. 1, 2, and 3), plants of a grass-green color, which, although belonging to the division of flowerless plants, and living in the water, are not now classed with algæ. They sometimes grow to be a foot or two long, and some of the species possess a peculiar and very disagreeable odor, which more nearly resembles the odor of certain sponges than any thing else. Several species are found near Boston; three species, including one which has a disagreeable odor, occurring in Fresh Pond, Cambridge. It might be supposed that the *Characeæ* would impart a disagreeable odor to water; but, as a matter of fact, the species are not abundant enough with us to produce any effect on the water, and, strong as the peculiar odor is at times, it is not easily communicated to water, even when the plants are growing in a confined space. Most of our species prefer ditches and places too shallow to be used as water-supplies.

We may next pass to a consideration of those algæ which

have a bluish-green color. As we have said, they, like the grass-green algæ, may be in the form of filaments, expanded masses, or may form scums on the top of the water. They may also float freely in the water; but in this case they do not, as in most of the *Desmids* and *Diatomes*, consist of single cells, but rather of aggregations of very minute cells united in colonies. The color is of importance, because, by its means, any person of ordinary intelligence can distinguish the present group of algæ from those already described; and while, as we saw, the latter are quite harmless, it is to the presence and decay of the former that we are able to ascribe the cause of some of the most decidedly disagreeable odors and tastes found in drinking-water.

The color has been described as bluish-green; but it sometimes assumes a purplish tinge, and at times becomes dark and almost black. Chemically speaking, the color is owing to a mixture of two coloring matters, — chlorophyl, the green coloring material of all common green plants, and phycocyanin, a bluish coloring matter, characteristic of the present group. These two different substances are mixed in variable proportions in the different species, and hence the different shades of color found. Phycocyanin is soluble in water: chlorophyl is not, but is soluble in alcohol. Consequently, if we put plants belonging to the present group into alcohol, it soon assumes a green color, owing to the extraction of the chlorophyl. If we bruise them and put them into water, or if they die while in the water, it becomes blue, often an intense blue, owing to the extraction of the phycocyanin.

In consequence of the injurious effect which they may have upon water, we may be allowed to describe, with considerable minuteness, the structure and mode of growth of the bluish-green algæ. They are placed by botanists in the order *Phycochromaceæ*, or, as it is sometimes called, *Cyanophyceæ*. The species belonging to the order are divided into two sub-orders, according as the cells of which the plants are composed are arranged regularly so as to form filaments, or are united together in colonies of no definite shape. The former sub-order is technically called the *Nostochinieæ*, or the family of the *Nostocs*, from the name of the genus *Nostoc*, which belongs to the sub-order; the latter is called the *Chroöcoccaceæ*.

In the remainder of this paper we will omit technical

expressions, as far as possible, and apply the term *Nostoc family* to the whole group of bluish-green algæ; asking the reader to bear in mind, that, botanically speaking, the word *Nostoc* applies only to a single genus of filamentous species belonging to the *Phycochromaceæ.*

Let us begin with an examination of some of the typical forms of the *Nostoc* family, which are represented in Plate II. The figures 4 and 5 represent respectively *Cœlosphærium Kuetzingianum* and *Clathrocystis æruginosa,* two species found diffused in the water, or forming scums upon the surface. These two species consist of a mass of jelly, in which are embedded the cells, which are bluish-green. We speak of such collections of cells as colonies, because, in a certain sense, each cell is capable of living by itself, and the dependence of the different cells on one another is not essential, as it is in the case of the cells which form the higher plants. The cells of the *Clathrocystis* are spherical; but those of the *Cœlosphærium* are oblong, and all have their longer axes directed towards the centre of the mucus in which they are embedded. The last-named species may be found in its earlier stages attached to the leaves and stalks of water-plants; and, in that condition, the colonies are small and nearly spherical. When found floating on the surface, they are generally lobulated as in Fig. 4, and are surrounded by a colorless film of mucus, which can hardly be well shown in a drawing. The film is often fringed by a halo of very short colorless filaments, or rather rods. The rods have no direct connection with the *Cœlosphærium* itself, but are caused by the action of small parasites, species of *Bacillus* and *Vibrio,* on the mucus in which the cells are embedded. A section through the *Cœlosphærium* colonies would show that the colored cells are confined to the surface, and that the interior is a mass of mucus or jelly traversed by bands of a denser substance than the rest of the interior. The *Clathrocystis,* Fig. 5, begins as a small solid body resembling the young *Cœlosphærium,* except in the size and shape of the cells composing it. The outer cells increase rapidly by dividing into two parts, each part growing to the size of the original cell. By repetitions of this process, the plant which was at first solid becomes a hollow mass of spheroidal shape. Certain portions of the surface then bud out from the rest,

and the whole mass becomes lobulated and irregular. The projecting buds or lobes then separate from the rest of the colony; and, as a result, we have what is represented in Fig. 5, a net-shaped bag of irregular outline. The lobes or buds which have fallen off so as to leave holes in the mother colony form new colonies; and the same mode of increase and budding is repeated in them.

In Fig. 6 is shown another species, *Lyngbya Wollei*, belonging to the filamentous division of the Nostoc family. The cells in this species are much larger than those in the two species already described, and are in the shape of disks. In the figure the cells seem to be narrow and somewhat rectangular; but the filament is in reality cylindrical, and the cells are packed together in the sheath very much as what are called lozenges by the confectioners are arranged in the paper in which they are wrapped. The figure is drawn so as to give a side view, showing the edges of the lozenges. Instead of being embedded in a spheroidal mass of mucus, the cells are arranged one over another, and enclosed in a gelatinous sheath. The figure represents merely a fragment of the plant; the filaments in reality being often several inches or even one or two feet long, and twisted together in rope-like masses, which are attached to sticks and plants in shallow water.

In Figs. 2 and 3 is represented another species, *Anabœna flos-aquœ*, often found associated with *Cœlosphœrium* and *Clathrocystis* in our waters. Fig. 1 represents a specimen taken from Basin No. 3 at South Framingham, Mass., in which the *Anabœna* and *Cœlosphœrium* grew mixed together. The filaments in the variety commonly occurring with us are much rolled up, as is shown in the figure. In this species the filaments are more complicated than in the others. Instead of being composed of cells which are all alike, they are of three different kinds. The ordinary vegetative cells are oval, and increase by dividing into two; interspersed at intervals one sees cells (Fig. 3, *b*), which are nearly spherical, and in the living plant are not bluish-green, but either colorless or slightly yellow. They are called heterocysts.

Still a third kind of cells, shown in Fig. 3, *a*, is much larger than the others. They are the spores, and are colored like the vegetative cells. As regards their function, the heter-

ocysts are quite inert, but the vegetative cells by dividing transversely increase the length of the filament. The reproduction takes place in one of two ways. In the first, the cells between two consecutive heterocysts escape from the rest of the filament, and each part thus separated, technically called hormogonium, forms a new plant. The second method of reproduction consists in the formation of new individuals by the germination of the spores. At a glance it will be seen that the spores are denser than any other part of the filament, and their cell-wall is much tougher. Although we have mentioned two forms of reproduction in the present species, they are not both found at the same time. When spores are found, one is not to expect to see the parts between the heterocysts separate from the rest, and float off to form new individuals. The spores, as a rule, are more abundant in the latter part of the season; and, when they are ripe, the other cells generally dissolve so as to leave them free. The spores themselves are heavier than the rest of the filament, and when free generally sink below the surface, either to the bottom or upon plants and sticks in the neighborhood. They do not usually germinate at once, but remain unchanged for some time. From the toughness of their cell-wall they are capable of resisting cold and dryness to a greater extent than the other cells.

Hence when the *Anabœna* grows in very shallow places, which are liable to dry up in summer or freeze in winter, the spores which have sunk to the bottom survive, while the other cells perish. With a return of the water and a sufficiently high temperature, the spores germinate, and form new plants, which may increase to an indefinite extent by the growth of the cells in the new filaments formed and by the formation of hormogonia.

The germination of the spores has not been observed in the particular species we are describing, but it has been observed in closely related species. In germination the outer wall of the spore ruptures, and the contents grow out in the form of a short filament, in which, by the formation of transverse partitions, cells of a cuboidal shape are formed. These cells once formed, it is easy to see how a filament of any length might be formed by repeated cross-divisions, and the growth of each new part until it has attained the normal size of the

Anabœna cells. The ordinary vegetative cells are first produced, and the heterocysts and subsequently the spores are produced by a direct transformation of some of the vegetative cells.

Having thus in a few species studied the typical forms and mode of reproduction of the *Nostoc* family, we are prepared to understand the changes which they undergo in decay, and the effects which they produce. In the first place, it may be remarked that all the species flourish in warm, or, better still, in hot weather. They may be found to a certain extent at almost any season; but they increase with great rapidity, and form masses of large size, more especially in the hot weather of July, August, and September. Then, to refer once more to what has been said about the reproduction: it should be borne in mind, that although the bodies to which the name of spores has been applied are found in some species, as in *Anabœna* for example, they have never been found in other species, as, for instance, in *Lyngbya* and *Clathrocystis*. Furthermore, the so-called hormogonia, or chains of vegetative cells which escape from the filaments in which they were formed, and become new individuals, are found only in the filamentous species, and are wanting in those which form solid colonies.

The formation of new individuals by a separation of lobules from an old one has been described in *Clathrocystis*, but we might still ask whether there is not some other way in which colonies like *Cœlosphœrium* and *Clathrocystis* may be propagated. At present no definite answer can be given to this question. Certainly no spores are known in the two genera last named. In *Cœlosphœrium* the cells sometimes separate from the jelly; but it is uncertain whether they grow to form new colonies, although they probably do. About all we know is, that old individuals of that genus, when confined in glasses of water, sink to the bottom, and remain inert for several months. That they are still alive, is evident: otherwise they would have decomposed.

If we turn now to a consideration of the effects produced by the members of the *Nostoc* family, we shall find that they are the cause of certain disagreeable conditions of our drinking-water. So long as they are living, and not excessively abundant, they produce no perceptibly bad effect on the

water; but when large quantities of them decay they give rise to the pig-pen odor, as it is called, which has in recent years caused considerable trouble and still more alarm. The character and extent of the trouble will be best understood by citing particular cases.

In the month of August, 1876, the water contained in Horn Pond, Woburn, which is the head-water of the Mystic water-supply, became very offensive. There was a very disagreeable odor, which resembled that of a pig-pen; and at different points in the pond were masses of slime of a bluish-white or yellowish color. At the time of our examination the slime was abundant; but we were told by Professor W. R. Nichols, at whose request the examination of the water was made, that it was less abundant than it had been the week before. The odor came, without any doubt, from the slimy masses; and the question was simply as to their nature.

A microscopic examination showed that the slime arose from the decay of a very large quantity of the filaments of some *Anabœna*. At the time of the examination the particular species could not be ascertained, because the plant was in a too advanced stage of decomposition. Besides the *Anabœna*, a large amount of *Lyngbya Wollei* was found at the upper end of the pond, attached to sticks and water-plants, and forming entangled masses on the surface of the water. This *Lyngbya*, which is peculiar to America, did not directly take part in the production of the pig-pen odor, at least in August, 1876; but in its entangled meshes was a large quantity of the *Anabœna* in a putrid condition. The results of the botanical examination were made public,[1] and since 1876 the condition of Horn Pond has been carefully watched by Professor Nichols. As far as is known, no trouble had existed previous to 1876; but it should be borne in mind, that the pond has only within a comparatively few years been used as a water-supply, and it is not to be supposed that we should have any record of trouble at a date previous to the appropriation of the pond by the cities of Boston and Woburn.

The circumstances which in 1876 tended to cause an unusual growth and ultimate decay of species of *Nostoc* were

[1] Remarks on some Algæ found in the Water-Supplies of the City of Boston: in the Bulletin of the Bussey Institution, January, 1877.

the intense heat of July and August of that year, — a heat which will not soon be forgotten by inhabitants of the Eastern States, — and the lowering of the water in the pond. As has already been said, the *Nostoc* family flourish in hot weather; and during July and early August of 1876 the *Anabœna* had increased to an unusual extent, only to be killed by exposure to the air and the burning rays of the sun when caught in the meshes of the *Lyngbya* or on stones and water-plants exposed by the falling of the water during the drought. In 1876 the pig-pen odor, although at first intense, disappeared in a short space of time. In less than three weeks the slimy masses had disappeared; and, in fact, after a fortnight but little was to be found. It is also to be noticed, that the slimy masses were not traced on the surface of the water farther down than the saw-mill in the town of Winchester.

Although a certain amount of *Clathrocystis* and *Anabœna* had been observed in Horn Pond since 1876, no serious trouble was again experienced until the latter part of July and August, 1879. An examination of the pond made on Aug. 2 showed even a larger mass of slime than in 1876. The water seemed to be full of *Clathrocystis*, but the *Anabœna* was not so abundant as in 1876. The upper part of the pond was especially offensive, yet there were several parties of men and boys bathing at the time of the examination. In 1879, as in 1876, the trouble lasted but a short time, not more than three weeks, and the offensive matter did not pass beyond the mill at Winchester. In 1879, however, the temperature had not been excessively high, — that is, not higher than might be expected any summer. The water had fallen about a foot, apparently in a short time. The fall in the water was shown by a tidal mark, if one may use the expression, indicated by a bluish color, found along all the rocky and pebbly part of the shore. The blue color was of course produced by the phycocyanin from the decaying algæ, and one can easily imagine the large amount required to stain the rocks and pebbles in the manner described.

So far, we have only spoken of the condition of Horn Pond; but similar troubles have occurred elsewhere. On Sept. 23, 1879, notice was received that a green scum had appeared on the surface of Basin No. 3 at South Framing-

ham. This basin had recently been constructed by damming a small stream in connection with the Sudbury-river supply, and is only a short distance from Lake Cochituate, whence the greater part of the water which supplies Boston is obtained. The persons in charge of the basin, knowing about the *Clathrocystis* of the Mystic Valley supply, inferred, judging by the color, that the plant in the basin was the same. A microscopic examination, however, showed it to be a different species, *Cœlosphærium Kuetzingianum*, but one very closely related botanically to the *Clathrocystis*. Associated with it was a quantity of *Anabæna flos-aquæ*, also found in Horn Pond. The reader is referred to Figs. 5 and 6 of Plate II., where both forms are well represented. The history of the *Cœlosphærium* is this. It appeared rather suddenly; and, although more or less abundant, no very great trouble was experienced from the pig-pen odor, probably in consequence of the lateness of the season.

The appearance of the *Cœlosphærium* having been unexpected, and the plant possessing a scientific interest, a regular examination was made of specimens sent in bottles to Cambridge from Basin No. 3. The examinations were continued from Sept. 30 to Nov. 15, at intervals of from two to four days, the irregularity of the periods of examination depending upon the fact that the bottles which were forwarded by express were not always punctually received. The examinations showed the constant presence of *Cœlosphærium* and *Anabæna*, but in quantities constantly diminishing, until the last-named date, at which time it was not considered profitable to continue the investigation longer, owing to the small amount of algæ then in the water. During the period of examination, there would occasionally be a day when the water in the bottles was quite clear; but in such cases it was probable that the floating scum had merely been blown temporarily away from the particular spot where the collections were usually made. The theory of persons living near the basin was, that the algæ had sunk to the bottom; but this belief, as far as we know, is not supported by the statement that masses of algæ had actually been found at the bottom near the spot where they had been previously floating.

The *Cœlosphærium* and *Anabæna*, after being confined in

the bottles for a few days, gave off a very disagreeable pig-pen odor, accompanied by a formation of a large amount of slime. Water containing a large proportion of slime was placed in glass vessels, and exposed to the air. In most cases in about ten days, but in a few not until the expiration of three weeks, the water became clear, with a small deposit at the bottom. The vessels were then covered with glass to prevent evaporation; and at the present date, Feb. 11, the water remains clear, and an examination of the deposit shows the presence of a certain amount of *Cœlosphœrium* apparently still alive, but pale in color.

An examination of the *Anabœna* found in Basin 3 disclosed a curious fact, and one which perhaps accounts for the disappearance of the species at some periods. It might seem to be improbable that such small plants as the *Anabœna* would be attacked by parasites. Such, however, is the fact. A small species of *Chytridium*, a genus of unicellular vegetable parasites, was found in abundance on the spores of the *Anabœna*, and destroyed them in large numbers. The species seems to be undescribed; but another species, *Chytridium cornutum*, which grows on the heterocysts of *Sphœrozyga circinalis*, was found by Professor Braun near Berlin.

Following the descriptions which have just been given of Horn Pond and Basin No. 3, we see that the three plants which have caused the pig-pen odor belong to the *Nostoc* family; the *Clathrocystis* and *Cœlosphœrium* being in the form of colonies, and the *Anabœna* filamentous. All three in their mature conditions form scums of a considerable extent, which are blown hither and thither by the winds, and ultimately either become entangled in the meshes of other algæ, and caught on the leaves and stems of water-plants, or are driven ashore or into very shallow places. They flourish, it is true, when the temperature is high; but a burning sun kills them, especially when they are exposed to the air, or do not float in sufficiently deep water. In decay, all the plants mentioned give off a jelly or slime which is often astonishing in amount. The phycocyanin exudes into and colors the jelly a light blue color; but, as the putrefaction advances, the jelly becomes yellow and finally brownish. The progress of decay, as we have said, is rapid; and the slime gradually dissolves in the water, giving it a slightly oily or greasy consistency.

The question arises, Are there other species, besides the three mentioned, which give off the pig-pen odor in decay? Certainly many, and perhaps nearly all of the members of the *Nostoc* family produce the same odor. We have found it in species of *Oscillaria;* and the *Lyngbya Wollei*, so common in Horn Pond, where it contributes but little to the stench which sometimes arises from that picturesque but filthy sheet of water, when confined with little water in a closed receptacle produces a strong pig-pen odor. We may here remark, that many members of the *Nostoc* family normally produce an odor which to some persons is very disagreeable. The odor cannot be well compared to any other, as it is quite peculiar. It is often noticed in swamps. *Lyngbya Wollei* possesses it in a slight degree when growing; and if the plant is quickly dried, and then re-moistened, the peculiar odor is very marked. Neither of the three species which are found floating on the surface so abundantly has the odor which we have just described as normal to some species.

In this connection it should be said, that, so far as is known, the so-called cucumber taste is not due to the growth or decay of any species of plant. In the autumn of 1875 the water in the Chestnut-hill Reservoir had a peculiar taste, which was popularly described as resembling that of cucumbers. At that time the water was examined by Professor W. R. Nichols, Mr. Edward Burgess, and myself; but no cause, chemical, zoölogical, or botanical, could be assigned for the taste. On the contrary, both chemical and microscopical examination showed that the water was unusually pure. For a detailed account the reader is referred to the "Report of the Cochituate Water Board for 1876," in which is a "Report on a Peculiar Condition of the Water Supplied to the City of Boston," by Professor Nichols, Dr. Farlow, and Mr. Burgess.

Another question is, Where have the three species in question come from? It is only very recently that they have attracted public attention, but they have been known to botanists for a long time. They are not peculiar to America, but are also found in Europe, where the *Clathrocystis* is very common on the surface of still, shallow waters, and it is found in all botanical collections. As long ago as 1856, it was recorded by Henfrey in England; but it was previous-

ly known in Germany, although it had never been well described.[1] It was found in the Ludlow Reservoir of Springfield in August, 1876, and is often found at Fresh Pond, Cambridge, where, in 1879, it occurred as late as Oct. 25; not to mention several localities outside of this State where it is known.

The *Cœlosphærium* is not so common in Europe as the *Clathrocystis*, but it is not rare. It was first described by Naegeli in 1849, and was found by him in a ditch near Zürich. What is now considered to be the same species was found by Unger in a basin in the Botanic Garden at Gratz, and was named by him *C. Naegelianum*. The species was fully described and figured by Leitgeb, whose material also came from Gratz.

With regard to the *Anabœna*, it is found in this State not only at Horn Pond and South Framingham, but also at New Bedford, where it occurs in the city water-works. It is also common in Europe; but, inasmuch as the species has been described under several different names, there is a little technical difficulty in deciding what name properly belongs to it. Our plant is the same as that called by Rahenhorst *Anabœna circinalis*, which is considered, apparently correctly, by Kirchner, to be only a variety of *Anabœna flos-aquæ* of Kuetzing.

The popular German name for all the floating algæ which form scums is "wasser-blüthe," or water-flowers. The expression, of course, includes our three common species; but it also embraces a number of other species of the *Nostoc* family, some of which, as *Limnochlide flos-aquæ*, are known to occur in this country, although they have not yet been recognized near Boston.[2] After what has been said, it is evident that there is nothing extraordinary in the apparently sudden appearance of the floating *Nostocs* in our water-supplies. They undoubtedly existed in small pools and

[1] Those interested in the structure of *Clathrocystis æruginosa* and its allies are referred to Cohn's remarks in Beiträge zur Biologie der Pflanzen, vol. i. part 3, pp. 156, *et seq.*

[2] An interesting floating species of small size, *Botryococcus Braunii*, has been detected by Professor S. A. Lattimore, at Rochester, N.Y. The species is also said to occur near Boston. It is not altogether unlike *Cœlosphærium* in appearance, but is grass-green instead of bluish-green, and is not placed by botanists in the *Nostoc* family. It would be interesting to know whether this species in decay gives off the pig-pen odor. It is, apparently, not very common; and no marked effect is produced by it on the water.

ditches, and very likely in places like Horn Pond, long before the public attention was attracted to them; and, if they were unknown to American botanists until a recent date, it was only because the latter had never turned their attention to the smaller flowerless plants.

The theory that the growth of *Clathrocystis* in Horn Pond was caused by the introduction into it of refuse from the tanneries in the neighborhood was adopted by many persons, and at one time threatened to assume a legal bearing. The theory is utterly untenable, so far as the direct influence of any thing discharged by the tanneries on the growth of the *Clathrocystis* is concerned. We know that both in this country and Europe the species abounds in places remote from all tanneries, or factories of any kind. If the refuse does harm, it is only by filling up the pond, and making it shallower. It is not necessary to look beyond the pond itself for a sufficient explanation of the trouble. Very shallow at the upper end, with a bottom of soft deep mud, from which grow weeds covered with *Lyngbya*, with a bar extending nearly across the central part of the pond, with a growth of lilies and other plants choking the already sufficiently shallow water, Horn Pond, during the summer months, can hardly be a fit source of water-supply.

In the case of newly-formed basins like that at Framingham, it is easy to see where the *Cœlosphærium* must have come from. The basin was formed by damming a small stream which was made to overflow a tract of lowland; so that, as it now stands, there is a considerable expanse of shallow water, not exactly stagnant, but with only a slight current, on a bottom composed of the mud and plants of the old meadow-land. If there were any members of the *Nostoc* family previously growing on the ditches in the lowland from which the basin was formed, they would be likely to spread, and form a scum on the shallow water of the sides of the basin, which must be raised to a high temperature by the sun's rays in summer.

Looking to the future, one may assert that no absolute remedy can be proposed in case of the ponds already affected. They should be cleared of weeds and substances in which the *Nostocs* may lodge; and, where it is possible to regulate the height of the water, it should not be allowed to fall

rapidly in the hot weather. Large and deep bodies of water are less likely to be affected than small and shallow bodies, and gravelly bottoms are better than muddy. The escape of steam or hot water should never be turned into ditches or streams connecting directly with water-supplies. When such is the case, there is a most luxuriant growth of species of the *Nostoc* family, and the water becomes very foul. As an illustration, one only needs to examine Alewife Brook near Fresh Pond, Cambridge, in summer-time, to see what a disgusting mass of vegetation can be produced in this way.

The question as to the exact amount of harm caused by the excessive growth of *Cœlosphærium* and *Clathrocystis* in the water-supplies is to be answered by physicians and sanitarians rather than by botanists. The water immediately affected becomes too offensive to drink; and the only practical question is, whether the disagreeable properties are conveyed any considerable distance. During the period of the trouble in Horn Pond last summer, great complaint about the water was made in East Boston, which is supplied by the Mystic system. Something is perhaps to be attributed to the imagination, as rather terrifying accounts of the state of Horn Pond were published in the papers at the time. But beyond this there was undoubtedly a real repugnance to the water. As to the possibility of purifying the water by filtering, and allowing it to stand some days in a reservoir, much good may be accomplished; but, judging from the experience of last summer, the water cannot be entirely purified by these means.

In one respect, the fears of the public may be set at rest. The theory that certain diseases, as fevers, are produced by germs of some low forms of plant-life, whether true or not, has no bearing on the present case. On the one hand, although we know that the species described in the present article do cause the disagreeable pig-pen odor, and do render the water at times unfit to drink, we know, on the other hand, that they do not cause the specific diseases whose origin is considered to be explained by the germ-theory. The germs, so called, are all species of bacteria, distinct from the *Nostoc* family and much smaller. The public should receive with very great caution any statements about the dangerous effect of bacteria in our waters; and, instead of worrying

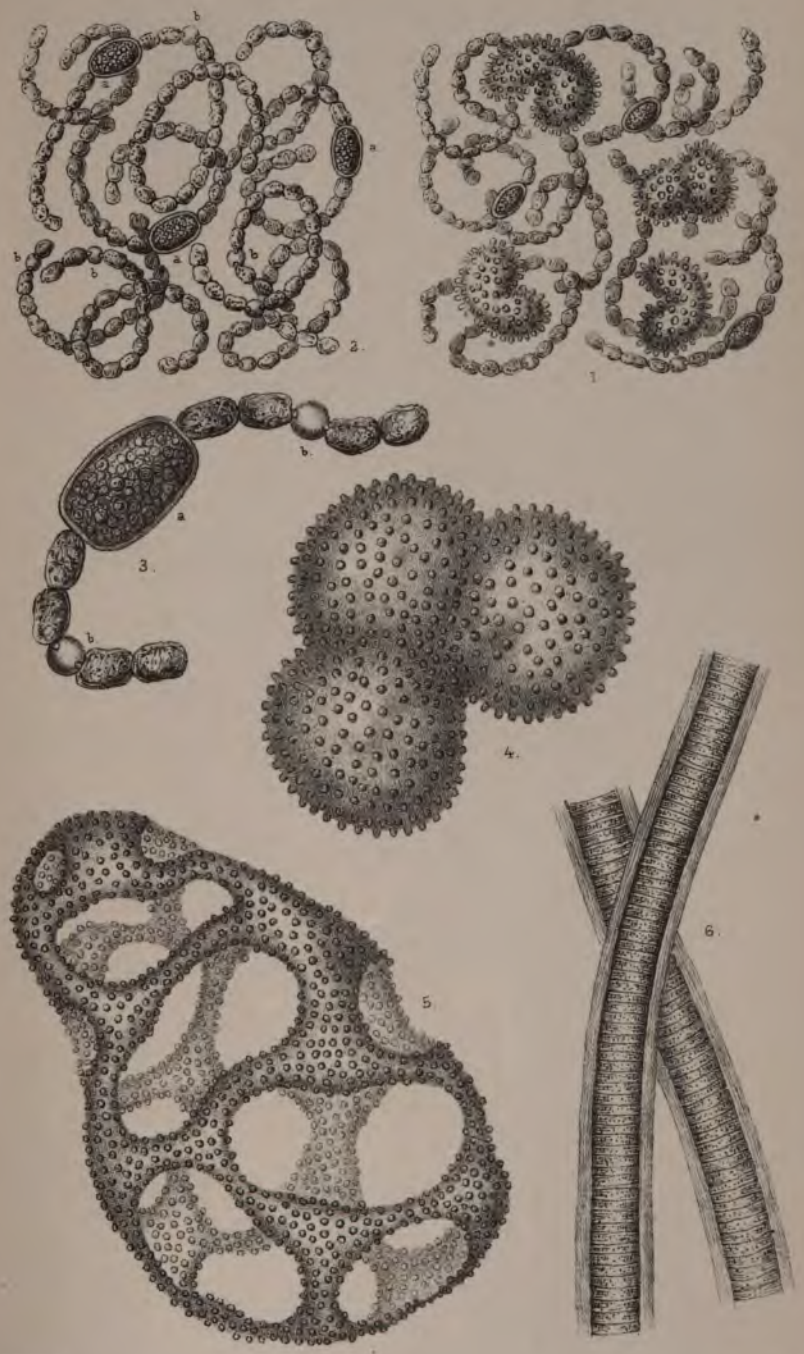
over the subject, had better leave the matter entirely in the hands of scientific people, who, at the present day, are the only persons who can be expected to follow the complicated and obscure relations of this difficult question.

In conclusion, we must mention one or two species which possess an interest in connection with those already described. One finds on the submerged iron of almost all water-works a rusty-colored, slimy plant. This is *Lyngbya ochracea*, or, as it is more frequently called, *Leptothrix ochracea*, a very much more delicate species than the *Lyngbya* shown in the accompanying plate. It does no harm to the water, as far as injury to its drinking-properties is concerned; but it is a great pest to paper-manufacturers, who require water free from all coloring-matter.

We must also mention a small group of plants, the *Beggiatoœ*, classed by some writers in the *Nostoc* family; although they are white, not bluish-green, when seen with the naked eye. The species of *Beggiatoa* are filamentous, and look something like a *Lyngbya* destitute of a sheath. They are characterized by the rapid vibrations of their filaments, and by the fact that they give off an odor of sulphuretted hydrogen. They are common in house-drains and sluggish ditches near factories, especially where the water is made warm by discharged steam or hot water. They are also found along the sea-shore, and abundantly in hot springs, and appear to the naked eye like very fine white films. Under the microscope the filaments are seen to oscillate, at the same time advancing or retreating; and in the cells themselves are dark granules which consist of sulphur.

From a botanical point of view, the floating *Nostocs* are very interesting; but it is usuallv difficult to get good material for study unless one is on the spot. The species of *Anabœna* are especially prone to break up and decompose when sent by express, and the various preservative fluids are of little use. To determine the species one should have the spores and heterocysts in position. The best way of preparing specimens is, by means of a pipette, to drop some of the water containing the plants upon a piece of mica or glass, and let it dry. The specimens can then be sent any distance; and, on re-moistening, the filaments swell up so that they can be well studied. If they do not at once recover their

Pl. II



C.E. Fawcett. del.

A. Meisel. Lith.

MEDICAL CORRESPONDENCE ON THE MYSTIC WATER-SUPPLY

IN

JULY AND AUGUST, 1879.

THE EFFECT ON HEALTH OF CERTAIN ALGÆ IN THE MYSTIC WATER-SUPPLY.

In order to ascertain to what extent, if any, the impurities of the Mystic water, during the summer of 1879, had affected the health of the people drinking it, the State Board of Health, Lunacy, and Charity sent to the physicians practising where the Mystic water is used, circulars with the following questions: —

1. So far as your observation goes, to what extent has the impure water been used for drinking, *unfiltered?*

To what extent, *filtered?*

2. Do you know of any facts — if so, please state them — showing that the unfiltered water is *injurious* to health ?

Or that it is *not injurious?*

3. Please state any facts coming within your experience, showing that the filtered water is *injurious* to health ?

Or that it is *not injurious.*

Thirty-three replies were received.

A great difference was found in the practice of different physicians as to the extent of the use of the unfiltered water for drinking-purposes.

Seven reported that the unfiltered water had been used, but without any evidence of its having proved injurious.

Seven, that very little had been used, and that there had been no indication of its being injurious.

Twelve replied that the water had not been used unfiltered, although the filtering generally amounted to imperfect straining, and that there had been no disturbance of health traced to it.

One reported that the water was imperfectly strained, and that no evil result followed from its use.

Five reported more or less illness from drinking the water unfiltered.

One failed to state whether the water was filtered in his

experience, but said that he knew of no illness attributable to its use.

There was no evidence, or even statement of opinion, that the filtered water was at all injurious.

The replies are as follows: —

DR. J. F. COUCH (of the Somerville Board of Health). I found it rather a difficult matter to answer the questions put by you, for the reason that it was hard to find any family that exclusively used, or abandoned the use of, the Mystic water. About the 12th or 15th of July, general attention was called to the condition of the water, and the people became very much alarmed at its appearance. Very soon they began to use well-water and spring-water, and for a while there was very little Mystic used for drinking. About July 22 the Board of Health invited the physicians of Somerville and vicinity to a meeting held in the City Hall for the purpose of learning, if possible, if the water had been the cause of sickness.

Considerable alarm was felt at the appearance in large quantities of "green matter" in the drinking-water. It was said to be the cause of a great deal of sickness. At the meeting there were present over twenty physicians, one of whom reported several cases of diarrhœal trouble in his own family, caused, he thought, by the Mystic water. (His family consists of four.) Another said he had several cases of diarrhœa and also a case of sore throat caused by the water. A third, who keeps an apothecary-store, reported having had an unusual number of calls for *mist. cretæ* thus far this season. A letter was read from one of the resident physicians at the McLean Asylum for the Insane, stating that they had had an unusual number of cases of diarrhœa to treat in the institution, caused, in his opinion, by the use of the water. None of the other physicians present had any such experience. At the time the meeting was called, there was an unusual freedom from intestinal trouble.

Well-water and spring-water are largely used for drinking, and but very little Mystic water. I have met a few persons who do not use Mystic water except for washing: the great majority use it for cooking, first passing it through a piece of cotton or cotton-flannel as a strainer. Up to the present time, I have not been able to find out how many wells are used: I find them in almost every part of the city; there are, I believe, very few new wells.

Some of the most persistent cases of diarrhœal trouble that I had to contend with this summer were using but little Mystic water, and that only after boiling and straining. Although decidedly opposed to the use of Mystic water while it is being polluted by the drainage of those tanneries in Woburn, I must confess that I do not believe that it was the cause of any of the diarrhœal cases that came into my hands this season. You may be astonished, in this connection, in looking over the following tables: —

DEATHS FROM GASTRO-INTESTINAL DISEASES.

1878.		1879.	
July	8	July	6
August	14	August	16
September	10	September	6
Total	32	Total	28

DEATHS FROM ALL CAUSES.

1878.		1879.	
July	32	July	36
August	33	August	44
September	31	September	27
Total	96	Total	107

DEATHS UNDER FIVE.

1878.		1879.	
July	17	July	15
August	23	August	26
September	15	September	10
Total	55	Total	51

I have made careful inquiries in forty families, with the following results: —

Two have used the Mystic water unfiltered all the time, *one* for the last four weeks, and *one* for the last two weeks; making a total of four families who have used unfiltered Mystic water.

Twenty-five have used it filtered. Of these, very few drank the water before boiling. The filtering consisted in passing the water through a flannel or cotton bag. They used the water chiefly for cooking.

Eleven families used well-water altogether. There are one hundred and forty-three persons in the forty families; and it appears therefore that nearly all of them used well-water or spring-water for drinking, which, so far as I know, have not been productive of any illness.

DR. T. M. HORD (Medical Director United States Naval Hospital, Chelsea). All water used in the hospital is first filtered through flannel. I have seen no ill effects from it.

DR. F. H. BROWN (United States Marine Hospital, Chelsea). The water has been used at the United States Marine Hospital, to my knowledge, for the past two years unfiltered. I know of no cases of injury to health from the use of the water: at the same time, knowing its character and the surroundings of the pond, I think it decidedly unfit for use by the community. The water, to taste, is certainly very inferior to Cochituate, and during the past few weeks it has been very disagreeable.

DR. F. W. PAGE (Medical Superintendent of the McLean Asylum for the Insane). The water was used unfiltered in the female wards until a large number of cases of diarrhœa supervened, which were directly attributed to drinking the water, and which speedily ceased on prohibiting its use.

Hon. A. J. Bacon (Mayor of Chelsea). Comparatively few of the inhabitants are using Mystic water for drinking. Large numbers go to Everett, and many use well-water: as many as three hundred were counted at one well in one day. The Mystic water has been very offensive. It is much better now; the main objection being not its taste and appearance, but the fact and thought of the large amount of animal *débris* in the lake. No actual cases known of disease arising from its use.

Dr. J. M. Putnam (City Physician, Chelsea). Only a very little Mystic water is used for drinking here. In one family, the head is a cook in a hotel. When he came home, he drank large quantities of unfiltered water: he had attack after attack of diarrhœa, and at last typhoid-fever. His wife and three children had the same bowel-trouble (not the fever), which ceased upon giving up the use of the water.

Dr. Horace C. White (formerly City Physician, Somerville). I know of no families who drink the water unfiltered: a *very few* drink it after boiling and filtering. I know of no ill effects from the unfiltered water, because it is not used; and none from the filtered, because it is so little used.

Dr. W. G. Wheeler (Medical Correspondent State Board of Health, Chelsea). I think the water is generally filtered before use; but a *very* large number of people go to the Everett spring, bringing the water away in barrels, pails, jugs, &c. A policeman is kept there to preserve order. I cannot recall any case of illness which I considered fairly attributable to the use of the Mystic water.

Dr. E. J. Forster (Medical Correspondent of the State Board of Health, Charlestown). I know of none who have not used the water unfiltered or filtered, and have seen no ill effects from its use.

Dr. M. B. Leonard (Correspondent of the State Board of Health, East Boston). A large majority of our citizens use unfiltered water. In July the Mystic water caused nausea and disturbance of the digestive organs of some of our citizens. The death-rate was not materially increased. Deaths from diseases of bowels commenced earlier this year than last. The number of deaths during the first six months of the year was ten more than for the same months in 1878. Diseases of the bowels have been far less prevalent in August this year than last. Cochituate water was substituted for Mystic water about July 23. The improvement in our drainage probably has more to do with the improvement in the public health than the change in our water-supply.

Dr. E. Jackson (Somerville). The larger part of the water has been used unfiltered, especially among the poor. During the months of July and August, many cases of diarrhœa have come under my notice, attributed to the use of the unfiltered water. I know of no ill effects from drinking filtered water.

Dr. S. Hanscom (Somerville). The people of my acquaintance who can do so have nearly all of them used well-water since the impurity of the Mystic water became noticeable: those who have not been able to get that have generally used filters. The poor people who do not use well-water generally content themselves with cotton or woollen strainers.

I do not think I can mention any thing reliable of illness attributable to the use of the unfiltered water. I have had one fatal case of typhoid dysentery, and the man was in the habit of drinking unfiltered Mystic water. I have not noticed any more than the usual amount of sickness this summer.

Dr. W. W. Dow (Somerville). I returned to my practice Aug. 24, since which time I have visited eighty-four families. In not a single case of sickness have I been able to trace the cause directly or indirectly to the use of Mystic water. Almost every family has a so-called filter, which in nearly every instance performed only the part of a simple strainer; the water is thus used for cooking and drinking, without any injurious effects. I do not know of a perfect filter in the city.

Dr. C. H. Shackford (Chelsea). I do not know of a family who use the water unfiltered.

Dr. C. T. Bean (Chelsea). In my opinion not more than one-fourth the population use Mystic water unfiltered, and one-half use it filtered; the other fourth perhaps use well-water and spring-water. I know no cases of sickness arising from using Mystic water, filtered or unfiltered.

Dr. A. P. Weeks (Chelsea). I know not more than three families who have used the Mystic water for drinking, either filtered or unfiltered. Its use has been so restricted, that we cannot expect to see much ill effect from it, however polluted it may have been.

Dr. M. W. O'Keefe (Chelsea). I know of no facts tending to prove the unfiltered water injurious; nor have I observed any thing that would lead me to think it not injurious, because of the universal abandonment of the water for drinking-purposes for the past six or eight weeks.

Dr. J. B. Fenwick (Chelsea). I know of no cases where the water has been used unfiltered. I have not been able to trace any injurious effects to the drinking of the water filtered.

Dr. W. R. Chipman (Chelsea). I have had a number of cases of dysentery which I think may be fairly considered due to the water, — children from two to seven years of age, — possibly due to the weather or other causes. Two-thirds of the people have got their water from other sources.

Dr. S. L. Morse (Chelsea). I have seen no cases of disease which I think can be attributed to the water, but believe it might cause it.

Dr. C. A. Holt (Chelsea). As a matter of *comfort*, the water unfiltered is unpleasant: I have seen no cases of illness from it, except that some persons returning from the country, who have drank the water in large amounts, have had diarrhœa. Perhaps any water would have had the same effect.

Dr. J. A. McDonald (Charlestown). Very little water has been used unfiltered; but in the majority of cases, the filter has generally consisted of a flannel bag. I have not found it injurious.

Dr. R. A. Blood (Charlestown). Unfiltered water has been used to a great extent; filtered, I should judge, to only a slight extent, and the filters have been of little use. My opinion is, that the water has not been injurious to health to any considerable extent, unfiltered. I know

of no facts showing that the filtered water is injurious: I cannot say that it is not so.

DR. JOHN S. WHITING (Charlestown). The water is always filtered, though not effectually; no injurious effects observed.

DR. S. A. DAVIS (Charlestown). Very few use the water unfiltered; a large majority filter it, and many boil it. In the early part of the summer I had some half-dozen cases of dysentery which I thought were caused by drinking unfiltered water.

DR. N. J. DAVIS (Somerville). I do not know of a single instance where the water has been used to any extent for drinking-purposes.

DR. J. F. WAKEFIELD (Everett) attributed six cases of dysentery to the use of the water, when it was soon covered with "green scum" upon standing a little while; it was hardly used, however, except for washing.

DR. THOMAS CROZIER (Charlestown). Three-fourths of the water used has been unfiltered, one-fourth filtered. I do not know of any facts showing that the unfiltered water is injurious to health.

DR. J. B. GOULD (Somerville). Very few families have used the water unfiltered: a small proportion have used it filtered and boiled for the past two months. I know of no facts showing that it has been injurious to health.

The replies above given are all from physicians whose names were appended to their answers. The remaining five contain no facts except as already stated in the summary.

In three replies, the statement was made that impure well-water had been resorted to with the result of producing illness.

THE DRAINAGE OF SUMMER HOTELS AND COUNTRY BOARDING-HOUSES.

BY

ERNEST W. BOWDITCH, ENGINEER,

OF BOSTON.

THE DRAINAGE OF SUMMER HOTELS AND COUNTRY BOARDING-HOUSES.

PRIMARILY let it be stated, that scarcely one of the hundred and fifty summer-houses recently examined (hotels, boarding-houses, and private dwellings) is in a really wholesome sanitary condition. Certain it is that on many of them money and time enough have been expended to produce the best results; but, from either ignorance or carelessness, a majority are far from what they should be. There is a general idea that what is out of sight is out of danger, and, provided sewage be delivered outside the walls of the house, that the arrangement is perfect.

The best summer hotel is generally understood to be one where the table is above criticism, where the chambers are well kept and airily situated, and where the general surroundings are agreeable. As for the sanitary arrangements, water-closets, set bowls, and bathrooms, if the house be modern, or privies, if more old-fashioned: such things are not to be mentioned, and the subject is dropped.

Unfortunately mankind is so constituted that privies, water-closets, or some substitute, must be made use of; and, such being the case, it would be as well if these matters were looked at squarely, and arrangements provided, whatever they may be, that at least will not be dangerous neighbors.

In looking over and testing the sanitary arrangements of summer dwellings, it is curious to see how the typical New-England privy and sink-drain have been perpetuated, either as a whole or in part, and how very few people have even attempted to improve in this direction. Occasionally a hotel-proprietor announces with pride that he has just purchased the very best water-closet that money will buy, or that all the faucets in the house are triple-plated and of

extra size; but it seldom occurs to him that possibly the soil-pipe into which the water-closet empties may be a condemned water-pipe, or that his faucets may drip into untrapped sinks, — that there is even a possibility of there being any thing wrong in the system.

To return to the primitive New-England conveniences. Many people will remember during their childhood, while passing a summer on a farm, those two institutions, the surface-privy and the kitchen sink-drain: the former disgusting enough both to the eyes and nose; the latter a harmless (?) lead or wood pipe or trough, either dripping on the ground, or carried, untrapped, to some unknown depth

A NEW-ENGLAND FARM-HOUSE.

beneath the surface. An unnatural curiosity, added to a desire to obtain bait for fishing, may have led them in dry weather to explore farther in the moist ground around the drain. If so, a barrel minus its head perhaps, was found sunk in the ground, filled with loose earth, — the primitive leaching cesspool in this country. The well, situated perhaps not over twenty-five or thirty feet from either privy or cesspool, so as to be "handy" to the house. Not unfrequently the farmer and his wife lived in a ground-floor room adjoining the kitchen, with one window looking out on the cesspool. "Nobody was ever sick in the house: in fact, the country was so healthy that people dried up and blew away — they never died."

This same style of privy and identical pattern of cesspool are to be found to-day doing duty for thousands of mechanics' houses, and for over ninety per cent of the summer establishments visited. Even hotels, accommodating as many as one hundred and seventy-five guests, have been met with, where modified barrel-cesspools (perhaps a set of them) were the only means of getting rid of the waste water.

Many of the larger houses are now introducing water-carriage with all the modern conveniences; but unfortunately the old leaching cesspool is retained, unless indeed it be possible to drain into some brook or pond, or the sea, thereby too often creating a nuisance. If there be a public water-supply, a larger quantity of water will be used, and the greater the difficulty in getting rid of it.

In addition to the dry-conservation and water-carriage systems, one frequently meets curious combinations of the two, — water-closets delivering their contents into privy-vaults, two or three story privies with vault-overflow connecting with water-closet soil-pipe, open untrapped wooden hoppers delivering into cast-iron soil-pipes, long untrapped lead wastes from sinks, bowls, and bath-tubs, delivering on the surface of the ground, or into sunken barrels, &c.

In spite of there having been in very many cases no sickness on the farm, these old-fashioned arrangements may not have been the best, after all. Imperfect arrangements may answer for one family, or involve no disease for a long time, while if quadrupled in size, or if used many years, they may become absolutely dangerous; but a suspicious case of fever or throat trouble is likely at once to be attributed to sanitary carelessness.

Early in 1878 the attention of the State Board of Health was called to the condition of the drainage at a large summer resort in Martha's Vineyard. Owing to the absence of the Secretary in Europe, however, an investigation was not begun until this year. The place was inspected in May, 1879, by Messrs. Hoadley and Folsom of the Board. The inquiry has been carried out under the direction of the Secretary, with the co-operation of the local board of health of Edgartown. The specimens of water were collected by the local board, examined chemically by Professor W. Ripley

Nichols of the Massachusetts Institute of Technology, and then passed upon by the Secretary of the Board, as also of the present State Board of Health, Lunacy, and Charity, upon whose opinion the local board declared wells good, fair, suspicious, or dangerous, as the case might be; some, of course, they condemned. The place was then inspected by the writer.

The late Dr. George Derby, then secretary of the State Board of Health, had directed the attention of the Board to this place several years previously in the following words: —

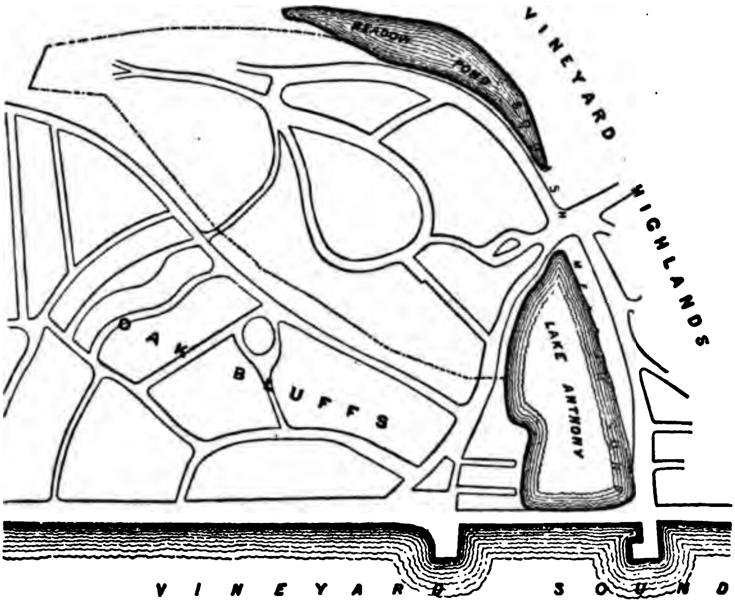
"The condition of the camp-grounds at Martha's Vineyard in the summer of 1869 was such as would lead an observer to predict that sooner or later they would be visited by pestilence. They certainly violate the plainest teachings of hygienic common sense. The buildings are so close together that ventilation is obstructed; they have no drainage; there is no adequate provision for the removal of refuse; the privies and wells are everywhere in close proximity; and most of the houses are so shaded by trees that direct sunlight can hardly ever reach them."[1]

The soil at the portion of the Vineyard examined is exceedingly porous, gravelly, or sandy, and will probably absorb as much sewage-matter as a majority of the soils to be met with in Massachusetts. The season when summer residents occupy their quarters ranges from forty to sixty days.

The privies are generally shallows in the ground or upon the surface, some of those belonging to "the corporation" being immense, unsightly, stinking affairs, emptied only once a year, during the absence of the summer residents. The odor at the latter part of the season is extremely offensive. The wells, unless otherwise specified, are driven wells, about half of them being of plain iron pipe, and the balance of galvanized pipe. Water is reached at from eight to twenty-five feet from the surface, the average being perhaps sixteen feet. Wells are usually driven several feet below water-level, occasionally even as much as twenty feet. The population of the "Cottage City" in midsummer is stated to be fifteen thousand, and, at the very height of the season, to reach double that number for a day or two at a time. The winter population is presumed to be not over three hundred.

[1] Second Annual Report of the State Board of Health of Massachusetts, page 144.

"Cottage City," as it is called, where the bulk of the Vineyard examinations took place, is made up of three distinct communities, — Martha's Vineyard Camp-Ground, Vineyard Highlands, and Oak Bluffs. It is situated at the northern end of the township of Edgartown, on the island of Martha's Vineyard. The name Oak Bluffs indicates in a general way the character of the shore, and the kind of forest-trees met with. The Camp-Ground has been in existence some forty years, as a camp-meeting ground; while Oak Bluffs, as any thing of a settlement, dates back to 1868. The Camp-



COTTAGE CITY, MARTHA'S VINEYARD.

Grounds and the Bluffs are only separated from each other by a high picket-fence, with gaps here and there for thoroughfares connecting the two, so that practically they form one village. The contour of the land is such that certainly one-half the area of Oak Bluffs drains naturally toward the sea; while the balance, and all of the Camp-Ground, tends to drain inland. Vineyard Highlands, like Oak Bluffs, slopes partly toward the sea and partly inland; or, more correctly speaking, toward the camp-meeting grounds.

At the north and west of the Camp-Ground, separating it

from the Highlands, are two fresh-water ponds, which receive the drainage of such portions of the village as does not find its way to the sea, or is not absorbed by the soil. The upper pond, or the one farthest from the sea, known as Meadow Pond, is connected with the lower one, Lake Anthony, though there is no visible outlet to the latter. Formerly, when the two sheets of water were one, and known by the more comprehensive though less æsthetic name of Squash Meadow Pond, and when the surroundings were more cleanly and less civilized, there was an outlet to the sea sufficient to change the water, to a greater or less extent, at every tide, though it is doubtful if the upper end was very much cleansed even then by the operation. Be this as it may, the outlet has been closed by the action of the sea; and in spite of the present filthy condition of the ponds, and their necessarily increasing nastiness, it has not been considered worth while to re-open it. From being sheets of pure limpid water, these two ponds are fast becoming sinks — veritable cesspools — for the filth created by the thousands of summer visitors whose cottages line their south shores. The upper end of Meadow Pond has been, owing to a "prudent" financial policy of the Camp-Meeting Association, filled in, partially, to allow additional house-lots; and, besides this, the pond appears to be silting up from natural causes. Rank marsh-grass, and masses of refuse, sewage, every thing that is nasty, can be found at the upper end. The southern bank of Lake Anthony is steeper, but presents a similar appearance, only to a less degree, owing perhaps to deeper water and a more cleanly set of residents. This bank, however, for the entire length of the two ponds, is a succession of wells and cesspools; and, as the lower extremity of the former is approximately coincident with the level of the bottom of the ponds, there would seem to be a possibility of a highly injurious action between the three, which for brevity may be summarized as: well, cesspool, pond, well. It is self-evident that such an abnormal state of things cannot remain so for an indefinite period without creating trouble, for the filth is certainly cumulative.

The cottages seldom have what are generally accepted as cellars. Some have small bulkheads built loosely of plank, but a majority have nothing. The houses are raised up on

posts, from a few inches to a few feet above the ground, in order to give a circulation of air sufficient to prevent decay of timbers. Some idea of the kind of building can be imagined when it is understood that numbers of them have only canvas roofs, and cost but one hundred and fifty dollars each, while others have many thousands of dollars expended upon them. Few are plastered, many have one coat of paint and stove-funnel chimney; and almost none, except the actual residents of the place, have any of the home comforts.

The roadways at Oak Bluffs, and possibly Vineyard Highlands, were arranged with some regard to the natural contours, but not at the Camp-Grounds. The avenues (by courtesy) are many of them lanes, where no thought appears to have been given, except to arrange for the present necessity; whole blocks of land now being below the streets (see No. 41, p. 185), and the drainage therefore being dependent entirely upon the wonderful absorptive properties of the ground.

The chemical examinations are given on pages 170 and 171, the wells having been selected generally from suspected localities, but still with reference to getting a fair idea of the whole. Remarks by Professor Nichols follow the table.

NOTE.

On the 1st of May the State Board of Health, Lunacy, and Charity called the attention of the Board of Health of Cottage City to the results of this investigation. May 16 a town-meeting was held, at which the following resolution was unanimously adopted: —

"That it is the sense of the citizens of Cottage City, in town-meeting assembled, that the Board of Health should adopt all proper methods to perfect and enforce stringent sanitary regulations in the town, and we will cordially sustain the Board in all reasonable efforts they may make in the furtherance of this end." — See also page 198.

Number.	DATE.	Ammonia.	Albuminoid Ammonia.	Total Solid Residue at 212° F.	Nitrogen as Nitrates and Nitrites.	Chlorine.	Chlorine. June 16.	June 20.	July 8.	July 22.	Aug. 14.	Aug. 29.	Sept. 12.	Oct. 10.	Oct. 17.
1	June 9 . . .	0.0037	0.0053	15.4	0.048	3.3	–	–	–	–	–	–	–	–	–
1	18 . . .	0.0005	0	19.1	0	4.7	4.8	4.8	3.6	3.4	2.8	2.8	2.4	3.1	3.1
2	9 . . .	0	0.0005	7.7	0.014	2.3	2.4	2.1	2.5	2.8	2.8	2.7	2.6	–	–
3	9 . . .	0.0037	0	11	0.207	3.4	3.0	3.5	3.9	3.9	3.7	3.6	2.6	3.3	3.4
4	– . . .	0.0088	0.0093	16.4	0.290	3.1	2.9	2.7	3.2	3.3	3.5	2.7	2.8	3.3	3.0
5	– . . .	0.0261	0.0104	22.7	0.211	7.8	8.2	7.9	8.8	–	–	–	–	–	–
5	27 . . .	0.006	0.005	–	–	–	–	–	–	–	–	–	–	–	–
5	July 11 . . .	0.009	0.032	9.0	–	Strong.	–	–	–	–	–	–	–	–	–
5	15 . . .	0.0023	0.024	10.6	0.411	3.0	–	–	–	–	–	–	–	–	–
5	28 . . .	0.0005	0.003	13.0	–	3.75	–	–	–	–	–	–	–	–	–
5	30 . . .	0.0015	0.004	12.5	Faint.	3.52	–	–	–	–	–	–	–	–	–
6	June 9 . . .	0.0016	0	10.1	0.236	3.2	3.1	2.7	2.5	2.8	3.0	2.8	3.5	–	–
7	– . . .	0.0179	0.0005	16.3	0.778	3.2	3.6	3.5	3.7	3.6	3.3	3.0	2.7	2.8	2.8
8	– . . .	0.036	0.0035	9.5	0.139	3.3	3.3	3.3	3.5	3.5	3.6	3.7	3.0	3.3	3.9
9	– . . .	0.0368	0.0061	49.3	1.868	16.7	13.2	11.4	–	–	–	–	–	–	–
9*	Oct. 29 . . .	0.003	0.005	8.0	–	2.2	–	–	2.3	2.3	2.5	–	–	–	–
10	June 9 . . .	0.064	0.008	27.4	1.293	6.0	6.0	5.8	5.5	5.2	–	–	4.3	–	–

11	June – . . .	0	0	7.1	0.111	2.4	2.9	2.6	3.1	2.9	–	–	–	–	–
12	– . . .	0.008	0.0053	7.2	0	2.7	2.7	2.6	2.6	2.4	–	–	–	–	–
13	– . . .	0.0085	0.0053	8.6	0.063	3.4	–	–	–	–	–	–	–	–	–
14	– . . .	0.0005	0	13.0	0.145	4.2	–	–	–	–	–	–	–	–	–
15	18 . . .	0.0701	0.0128	20.5	0.956	4.6	–	–	–	–	–	–	–	–	–
16	– . . .	0.0005	0	10.1	0.036	3.2	–	–	–	3.2	3.5	–	–	–	–
17	– . . .	0.0051	0.0067	13.9	0.152	4.3	–	–	— Second heavy rain July 4. —	–	–	–	–	–	–
18	– . . .	0.0005	0.008	11.3	0 443	2.7	After rain.	–		–	3.3	3.0	3.1	3.1	3.0
19	July 6 . . .	0.0053	0.0085	25.5	0.992	4.8		–		–	–	–	–	–	–
20	– . . .	0.0048	0.0013	7.2	0.075	2.7		–		–	–	–	–	–	–
21	– . . .	0.0139	0	14.1	0.227	3.6		–		–	–	–	–	–	–
22	– . . .	0.153	0	26.5	1.435	5.7	–	–		–	5.8	5.8	7.2	–	–
23	– . . .	0.0347	0.0032	17.2	0.880	3.5	–	–		–	–	–	–	–	–
24	– . . .	0	0.0005	10.3	0.034	3.5	–	–		–	–	3.6	3.5	–	–
25	– . . .	0.0627	0.0128	18.8	0.212	3.6	–	–		3.7	3.9	–	–	–	–
26	22 . . .	0.0053	0.0027	14.5	0.450	3.5	–	–		–	–	–	–	–	–
27	Aug. 29 . . .	–	–	–	–	–	–	–	–	–	–	3.9	–	–	–
28	Sept. 13 . . .	–	–	–	–	–	–	–	–	–	–	–	6.2	–	–
41	Oct. 29 . . .	0.042	0.009	13.7	–	4.8	–	–	–	–	–	–	–	–	–
42†	– . . .	0.000	0.008	39.2	–	5.1	–	–	–	–	–	–	–	–	–

* Driven in a new place.

† From a private well in Edgartown village, two privies 25 and 29 feet distant.

"The waters were generally clear, but in a few cases there was some turbidity due to the fact that they contained a ferrous compound (or proto-salt of iron), which on exposure to air rusted, and deposited a red sediment of hydrated oxide of iron (ferric hydrate). The waters which were already turbid when received were Nos. 8, 9, 15, 16, and 20. The following deposited some hydrated oxide of iron when warmed, and the residue on evaporating the water was more or less red in color: 4, 5, 7, 8, 9, 11, 12, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25. It is worth noting, that, while in a number of cases the ferric hydrate thus deposited contained traces of manganese, a considerable quantity of this element was found to be present in Nos. 5, 10, and 25, notably in Nos. 5 and 25.

"The residues obtained by evaporating the waters were heated, but the 'loss on ignition,' which is usually tabulated as 'organic and volatile matter,' is not given; the results are of no value in such waters as these. Even by gentle heat the mineral matter is decomposed, and the partial decomposition of the chlorides is evidenced by the acid smell which is readily perceived when the residues are subjected to a low red heat. The deportment of the residues was, however, noted, and a slight blackening was observed in Nos. 1, 2, 5, 6, 8, 12, 13, 14, 15.[1] No one of the residues betrayed the presence of offensive organic matter when burned. Qualitative analysis showed that there was considerable difference in the composition of the mineral matter in solution in the various waters: thus Nos. 4, 5, 14, 25, contained a marked amount of sulphates; Nos. 1, 4, 9, 14, 19, 22, 25, a comparatively large amount of lime compounds. Nos. 4, 25, contained a marked amount of carbonates. No quantitative determinations were made, other than of the nitrates and chlorides.

"The nitrogen as nitrates and nitrites was determined by a modification of Crum's process, proposed and employed by Dr. Frankland in the analysis made for the River's Pollution Commission in England.

"*Nitrates.* — Nos. 7, 9, and 10 showed the presence of nitrates by the sulphate-of-iron test at once and without concentration.[2] After some time a slight re-action[3] was obtained with Nos. 3, 4, 5, 8, 11, and 13; Nos. 1, 6, 12, and 14 did not contain enough nitrates to show by this test in the unconcentrated water.

"*Solid Residue from Evaporation.* — Nos. 1, 3, 10, and 14 left on evaporation a white residue. Nos. 4, 5, 7, 8, 9, 11, 12, and 13 left a yellowish or brownish residue, owing to the presence of oxide of iron."

The facts as ascertained were placed in the hands of the writer by the State Board of Health, Lunacy, and Charity, with the request that he would prepare a paper on the subject of the drainage of country hotels and boarding-houses. A careful inspection of Cottage City, Martha's Vineyard, was therefore made; and portions of Lynn, Nantasket, Cohasset,

[1] Also in No. 9 of Oct. 31, 41 and 00; scarcely any in No. 5 of July 29, blackening in No. 25; decided blackening in No. 5 of July 16.

[2] As viz. Nos. 19, 22, and 23.

[3] Also in No. 9 of Oct. 31, and a strong re-action in 41 and 42.

Natick, Swampscott, and Marblehead, were also carefully examined, including some of the more frequented summer-resorts. The facts ascertained in these places are fairly represented by the cases given; others would be merely cumulative.

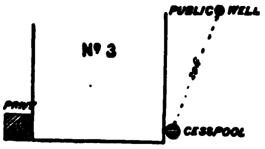
All the wells investigated in Martha's Vineyard are described in the following notes, and also other places where sanitary condition presented instructive facts illustrative of points bearing upon the general inquiry.

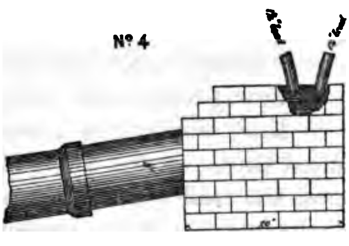
The numbers given on previous pages, 170 and 171, in connection with the results of chemical examination, correspond with the same numbers in the following description.

No. 1. A surface well, much used by the public. Green wooden pump. Distance from salt water, sixteen hundred feet. Nine feet from surface of ground to surface of water. A three-story sink-drain and one barrel cesspool (?) within thirty-one feet, but otherwise not exposed to sources of contamination within sixty feet.

No. 2. A wooden pump and surface well. Twelve feet to the surface of the water. Distance from the salt water, sixteen hundred feet. The surroundings appear good for a radius of one hundred and fifty feet.

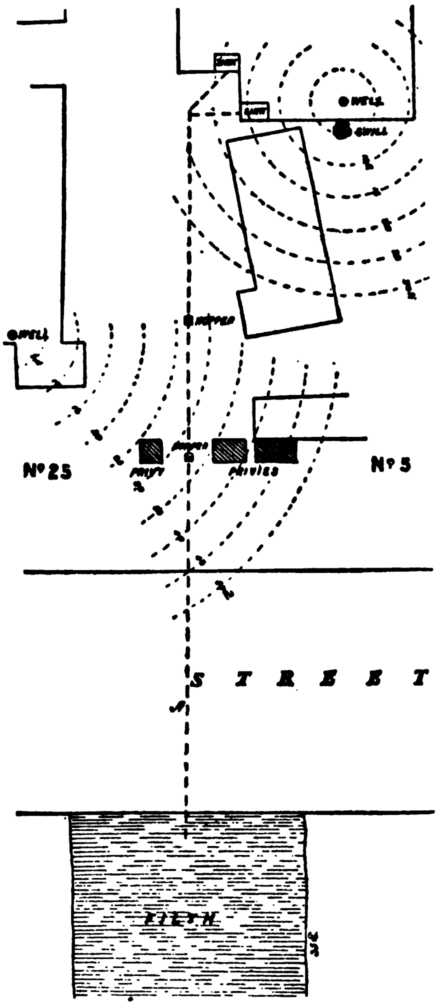
No. 3. A surface well with wooden pump. Twenty-one and one-tenth feet to surface of water. An exceedingly offensive barrel cesspool was found twenty feet distant on slightly lower ground. The cesspool contained two feet of a filthy fermenting kitchen-waste. Privy thirty-four feet away, as indicated. Distance of well from salt water, eleven hundred feet. Ground cemented for several feet around the well.





No. 4. A large public house. Well near the centre of the house; supposed to be at about the depth of the surface of fresh-water pond near house. Kitchen-sink delivers waste six and four-tenths feet from the well, into a small square brick cesspool, with eight-inch vitrified-pipe overflow. Sixty-two feet back of well, in rear

of house, are said to be five large leaching cesspools, bricked up and arched over, connected with each other. Four surface privies within fifty feet of the well. Incidentally, it may be mentioned there are no traps to the kitchen-wastes, and the joints between waste and main drain are as shown in the plate. Apparently there is direct ventilation into the house from the five cesspools referred to. Proprietor has taken pains to have every thing cleanly, and sufficient money has been expended to have satisfactory work. The house adjoining empties two privies into a cement trough, which in turn discharges into a cesspool. Surface well is stated to be within three feet of one privy, covered up so that it cannot be seen. Distance of well from salt water, thirteen hundred feet.

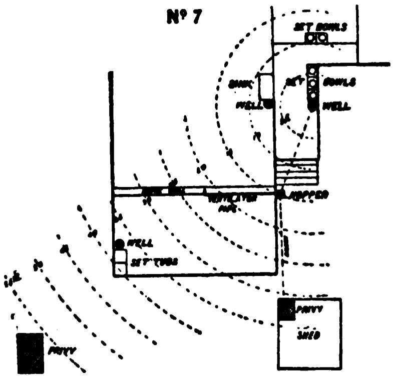


No. 5. A large public house adjoining No. 25, and next but one to No. 15. Swill-barrel kept almost touching the well, because it is "handy." Kitchen and dining-room sinks (trapless) empty into a rectangular box-drain of several different sizes, over one hundred feet long. Delivery of drain across the road in rear. Mass of filth across the street several inches deep. Drain opened as far back as A, and found to be entirely choked with filth. Proprietor states it is "hoed out" every autumn. Some thir-

ty feet from the upper end of the drain is a square wooden slop-hopper, and another some sixty feet from the same point, both disgustingly sour. Two privies, the nearest fifty feet from the house. Air-slacked lime and copperas are freely used everywhere. Mass of filth less than four inches above high tide, and within a few feet of the upper end of fresh-water pond. Cellar of house (a wooden bulkhead with loose plank floor) five inches above the level of the filth. Standing water in the cellar at all times. It is stated that the well in question was driven ten feet deeper after the first analysis proved the quality to be bad, and a second ten feet after further unsatisfactory results had been obtained. The interior of the house, and general surroundings other than those indicated, are exceptionally neat and clean. It is difficult to see where the well in the immediate vicinity could be located where it would be farther removed from objectionable surroundings. Distance of well from salt water, two thousand and eighty feet.

No. 6. Public well, wooden pump, surface well. There are no unpleasant surroundings for seventy feet or more. Distance to salt water, fourteen hundred and forty feet.

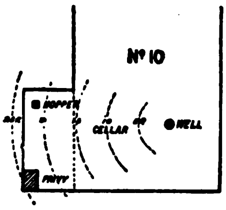
No. 7. A large public house. Three driven wells, one for laundry, one for kitchen and general plumbing, one for drinking. Analyses from the drinking-well. Kitchen-well seven feet distant. Wastes from five set bowls run to a wooden trough, that passes between drinking and kitchen wells. Large slop-hopper enters, untrapped, about twenty-five feet from the upper end. Plumbing from upper stories, &c., apparently connects just below hopper. Privy with tight (?) vault thirty-five feet from both wells. Air pipe from drain just below (?) hopper passes to kitchen-chimney. Distance of well from salt water, seven hundred feet.



No. 8. Public well. Several surface privies within a

radius of fifty feet, and one cesspool (doubtless others) are perhaps the factors in this case. Distance of well from salt water, eleven hundred feet.

No. 9. A private house. The well, twenty-five feet deep, was originally within a short distance of both privy and cesspool (twelve feet). Since the analysis it has been moved some fifteen feet, and driven ten feet deeper than before. It is too near even now. Distance from the well to the salt water, sixteen hundred feet.



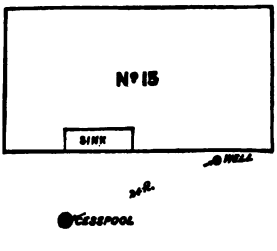
No. 10. Private house. The cellar of the house is excavated a few feet below both privy and hopper; and the well, being driven in the cellar, is at a lower level than either. Sink-waste runs toward the hopper from just beyond the well. Distance of well from salt water, six hundred feet.

No. 11. On the bluff. Not examined. Distance of well from salt water, six hundred feet.

No. 12. Private house. Sink-drain and cesspool within twenty feet of well. Surroundings very neatly kept. Distance of well from salt water, eleven hundred feet.

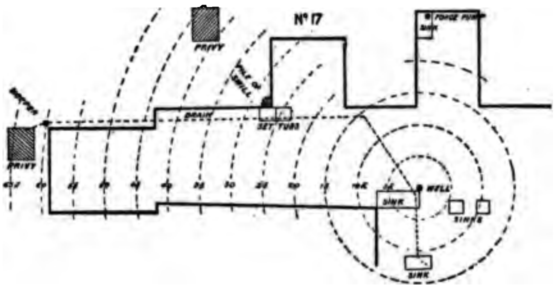
Nos. 13 and 14. Private residences in Edgartown, not examined.

No. 15. From a bakery. Sink-drain and cesspool apparently within twelve feet of the well. Some fresh earthwork had just been done previous to visit, so that the distance could only be approximated. It is said that formerly the cesspool was only distant from the well the length of an ordinary kitchen-sink, some three feet. Distance to salt water, 2,110 feet.



No. 16. Surface-water, sinks, &c., apparently all run to the vaults. Privies, ten in number, are forty-two feet from corner of house. No traps on any of the drains. Pump seventy feet from vaults. There are probably several others in the establishment, as there is a steam-pump, &c. Not a very good examination; the house being closed, and shutters up. Distance of well from salt water, one thousand feet.

No. 17. A public house. No cellar under the rear of the house, but building is so near the ground as to render a good examination impossible without tearing up floors. At least two wells. Dining-room sink and kitchen-sink pass to cement pipe laid with dry joints (?) Pipe within three feet of drinking-water well. A ragged hole five by six inches allows a one-fourth-inch kitchen-waste to enter. It is made a tight (?) joint by a block of wood and the scoop of a tin



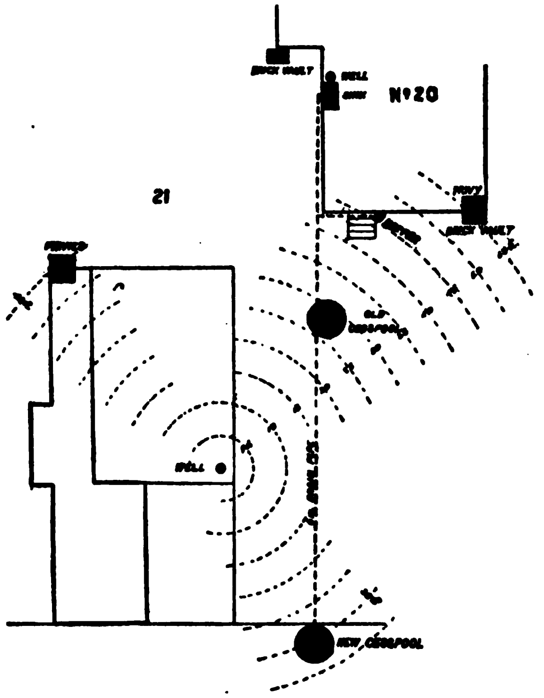
dipper. At some time the drain has run so full, or so much has come down from the kitchen-waste, as to spatter half way to the pump. Two small sinks in the dining-room drip through to the ground. Swill heaped against the house within thirty feet of well. Privy-vaults ventilate directly back into the house (?) Distance from the well to salt water, six hundred and fifty feet.

No. 18. The nearest nuisance is a privy, forty-five feet distant. Distance from salt water, one thousand feet.

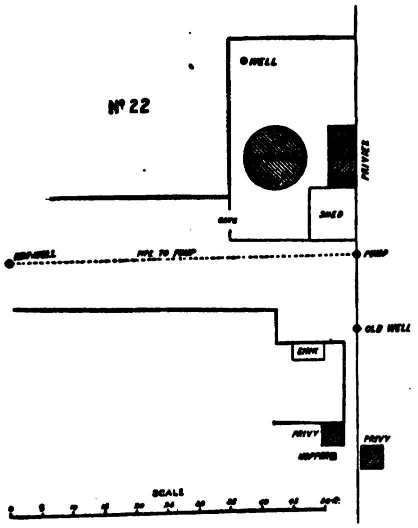
No. 19. Private residence in Edgartown village. Not examined. Privy nine feet, sink twenty feet, barn-cellar seventy feet, from well.

Nos. 20, 21. A case of typhoid-fever at the latter. At No. 20 is the only comprehensive arrangement of drainage yet seen on the island. The sink is trapped by a cylinder trap, and connects with a vitrified main drain. Enamelled-iron hopper, covered and trapped, connects with same. Vaults of brick, and apparently tight. Cesspools said to be of brick, with open bottoms. Level of surface of well at 21 lower than any of the surrounding ground or streets: no possible surface-drainage away from it. There is no visible kitchen-waste at 21. Distance of well from salt water, eight hundred feet.

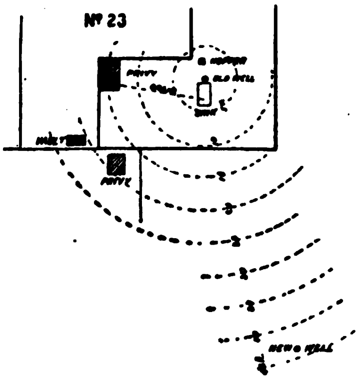
No. 22. The situation of the pump has always been as



shown, — the wells being connected by horizontal pipe. The old well first used had within twenty-five feet six privies, one slop-hopper, one barrel cesspool, and one large brick cesspool ten feet across and ten feet deep. At its new location it is still within fifty feet of both cesspools. The hopper is particularly foul. A well fifteen feet on the other side of the large cesspool (marked well) exhibited very curious (?) phenomena. During the past season an ice-cream saloon



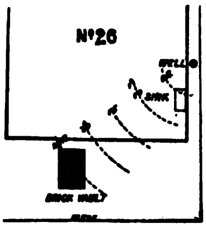
was located in the building next the large cesspool; and it was sometimes noticed, that, after pouring the waste from the freezers through the sink-drain to the large cesspool, the *well-water tasted perceptibly salt!* (Statement of a neighbor.) A partial examination of the cesspool showed that the walls were but four inches thick, of soft brick, and twenty-seven were missing on the side nearest the well in question. Distance of salt water from well, nine hundred feet.



No. 23. No comment is necessary: the plan explains itself. The well and privies were all surface affairs, and exceedingly offensive. The new well-water appears to be of very much better quality, and for an obvious reason. Distance of well from salt water, seven hundred feet.

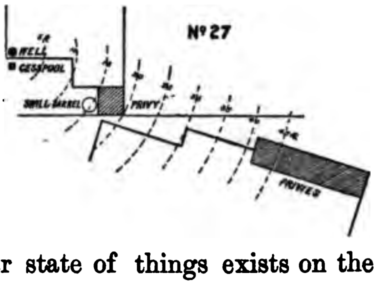
No. 24. Not examined.

No. 25. This adjoins No. 5, and the same general remarks would apply to one as the other. The premises are not neatly kept, and the well is much nearer offal of all kinds than No. 5.



No. 26. A good brick vault, and no cesspool visible on the premises. Sink-waste seems to empty into a neighbor's cesspool. General appearance of the surroundings cleanly. Distance to salt water, seven hundred feet.

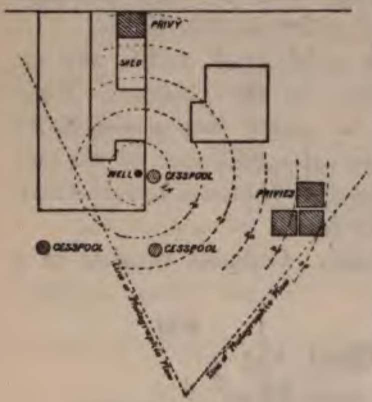
No. 27. Sickness in the house. Cesspool consists of a starch-box with the bottom knocked out, two feet and one-half from well. Swill-barrel fifteen feet, surface privy less than twenty, row of privies within fifty feet. The latter on lower ground, and should drain the other way. Very possibly a similar state of things exists on the



other side of house: not able to examine, however. Distance of well from salt water, eight hundred feet.

No. 28. "EVERY PRECAUTION TAKEN AGAINST SICKNESS."

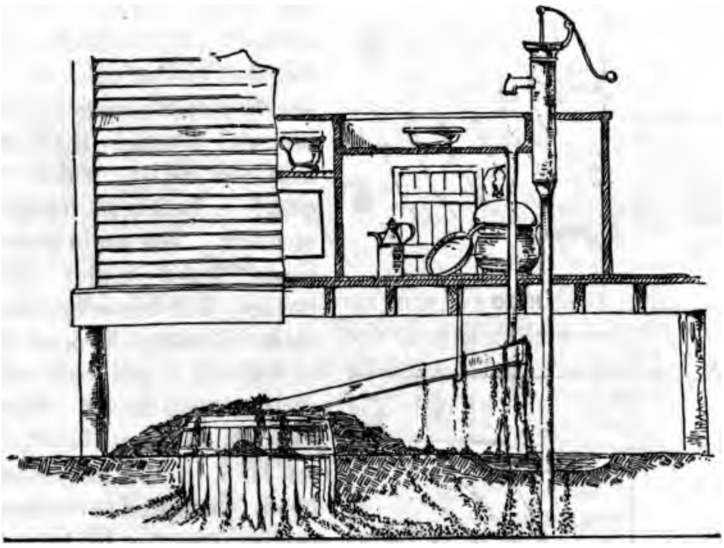
No. 28. A case of typhoid-fever. The neighbors state that every precaution for good health has been taken. Cesspools exceedingly foul. The nearest is within one foot four inches of the well, and three within less than twenty feet. Elevation view is as nearly as possible a copy of photograph. Cesspools dotted on. A well, not shown, in the right-hand lower corner of plan is No. 18. Distance of well from salt water, one thousand feet.



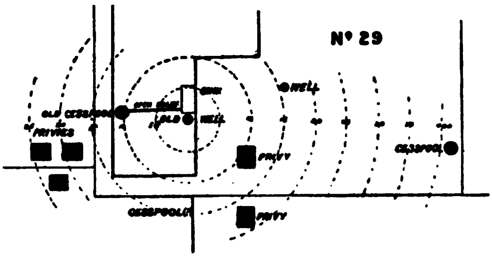
N°28

No. 29. Pointed out to the writer, but not examined by the Board. A large boarding-house. Old well within one foot of sink-drain. Sink-drain is an open trough running to barrel cesspool ten feet

distant. Barrel covered on top. In process of time it has become filled, and the waste has backed up the trough, till, at



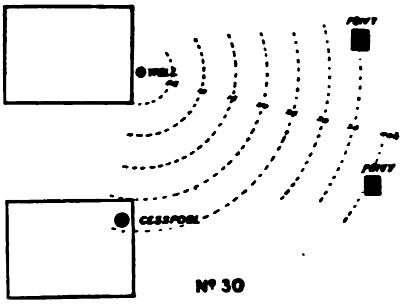
the time of the writer's visit, the entire trough was solid and covered with thick mould. Every thing passing from the sink settled immediately around the well; a very filthy puddle there at the time of visit. Finding the water tasted "funnily," the proprietor drove a second well some fifteen feet off as shown. A member of the local board of health states there are undoubtedly a number of just such cases. Distance of well from salt water, one thousand feet.

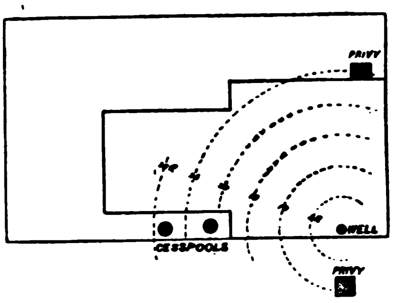


No. 30. Wells and their surroundings, taken at random in Oak Bluffs. Cesspool near top of street exceedingly foul. Persons state that the water tastes "beautifully." Distance of well from salt water, twelve hundred feet.

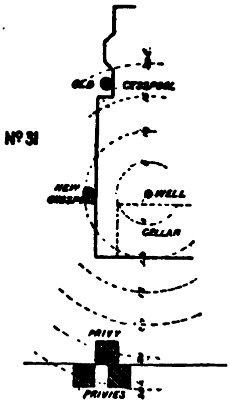
No. 31. Well selected at random in Vineyard Grove. Proprietor states the old cesspool was unsightly, being directly under the parlor-window, touching the house, and

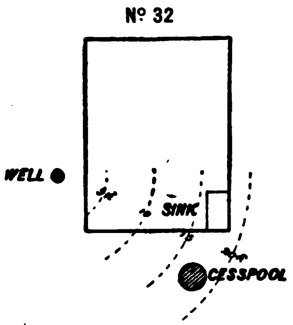
only partially covered with a board. The new cesspool is perhaps a trifle near his chamber for comfort, as the smell sometimes keeps him awake! (It is to be moved five feet farther off.) It is barely possible some of the material leaches through into the cellar, which is simply a bulkhead formed of plank. The drain sometimes leaks under the house. The house-lots are thirty by sixty feet, so it is difficult to get well and cesspool very far off. This house is on about the highest land in the neighborhood. I counted seventeen privies from the back-door of the house. Privies in the vicinity sometimes emptied once a year, sometimes once every two years.



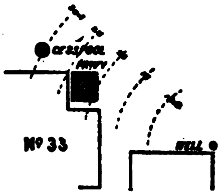


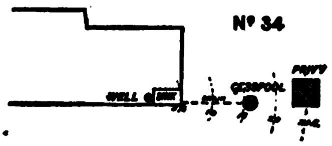
No. 32. Well selected at random. A hogshead cesspool covered up. Never been cleaned out. No trap on sink-waste. Ventilation of cesspool back into house. Water within five feet of the surface. Well seventeen feet away from cesspool. No privy at all: either borrow a neighbor's, or use public one within one hundred and fifty feet. House occupied all the year. The well, fifteen feet deep, is noted for its beautiful water, and is much used by the neighbors. Distance of well from salt water, twenty-six hundred feet.





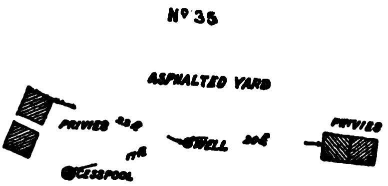
No. 33. Well selected at random. Cesspool cleaned out twice in the year. Well about eight feet deep. Galvanized pipe. Lots less than thirty by sixty feet. Distance of the well from salt water, twenty-seven hundred feet.



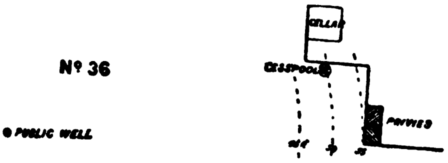


No. 34. Well selected at random. Open V-shaped wooden drain from house to barrel (?) fourteen and one-half feet from well. Privy twenty-one feet from the same. Distance of well from salt water, twenty-six hundred feet.

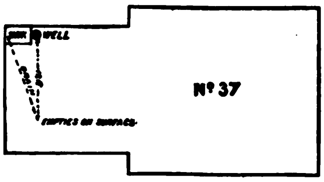
No. 35. Well selected at random. Four privies and one cesspool within twenty-five feet of the well. Water supposed to be used by five families. Distance from salt water, seventeen hundred feet.



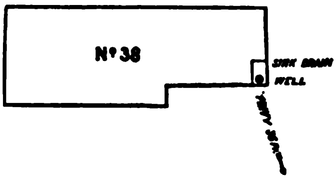
No. 36. A public well. Not very much used, being out of the way. On lower ground than the land on three sides. Cesspool seems to leak into cellar of house, three feet and one-half distant, and ventilated into both first and second stories of house through square box-drain. Distance of well from salt water, twenty-six hundred feet.



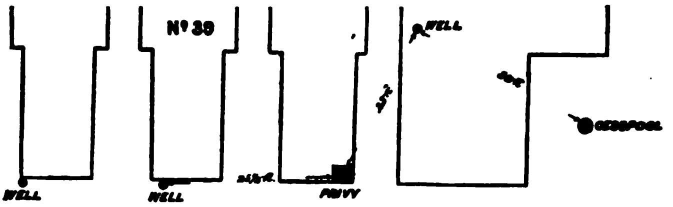
No. 37. Well selected at random. People say that a neighbor, distant some sixty feet, has no cesspool, and his kitchen-waste fouls their well; that their own kitchen-waste is clean water.. There is a decidedly objectionable-looking puddle, however, under the house, of pearl-colored liquid. Distance of well from salt water, twenty-six hundred feet.



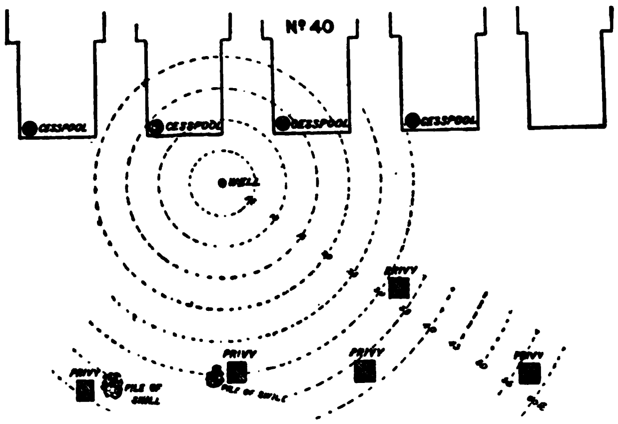
No. 38. Well selected at random. Sink-drain drips on the ground within three feet of well — not even a barrel to receive it. Family consists of three. There is no privy at all: privy of the next house used. Well is on slightly higher ground. Sink-drain foul, bad-smelling. "*Splendid water!*" Distance from salt water, twenty-seven hundred feet.



No. 39. Wells selected at random. Three houses without any visible drainage whatever. Distance of wells from salt water, about twenty-two hundred feet.



No. 40. Well selected at random. This well seems to be used by at least four families, and possibly by six or seven. Nearly level ground. The surroundings are not agreeable. Distance from salt water, twenty-two hundred feet.

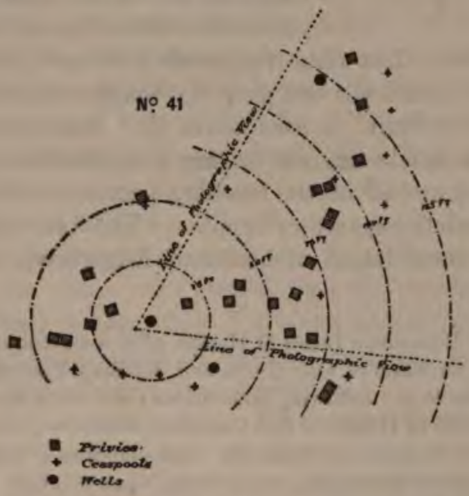


No. 41. Well selected by the writer after examining the plan of Martha's Vineyard. The elevation is pen-and-ink copy of photograph taken on the spot. Twenty-four privies

and thirteen cesspools within a radius of one hundred and forty feet, — better perhaps to say, within an area of one-

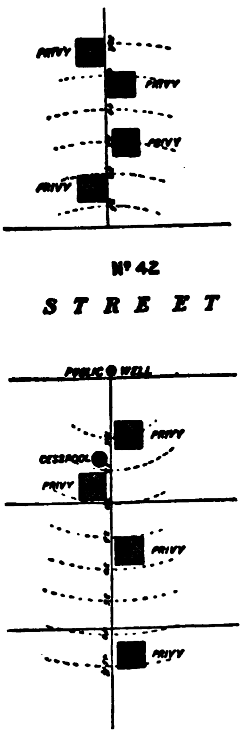
No. 41. SURROUNDINGS OF A WELL ON MARTHA'S VINEYARD.

third of an acre. Probably there are two more privies and



thirteen more cesspools, but they were unnoticed; and the houses being many of them boarded down to the ground,

made a careful examination a longer operation than it was thought advisable to give. The well from which the photograph was taken seems to be used by a number of families. The topography is such that nothing falling on the surface of the ground can drain away from the wells. The locality had never been noticed by the local authorities. Distance of the well from salt water, fourteen hundred feet.



No. 42. Selected at random. A public well giving very nice (?) water. Never been even suspected. Fourteen privies counted from this well; all within "range." Distance of well from salt water, twelve hundred feet.

In General.

But one single instance was noted where a drain was properly trapped. Undoubtedly there are a great many as well arranged as competent persons can make them; but an overwhelming majority are either entirely untrapped, or so insufficiently as to be well-nigh worthless. But *three* really efficient tight privy-vaults were met with, and not one properly built cesspool. The phrase "properly built" is used advisedly. There are several, that, so far as bricks and mortar are concerned, are good enough; but they are all of the leaching pattern, and almost invariably unsafely near water-supplies. The following order, issued by the local board of health of Edgartown, is self-explanatory: —

"The Edgartown Board of Health, after a careful examination of the sanitary condition of Oak Bluffs and Martha's Vineyard Camp-Ground, have come to the following conclusions; and they are sustained by the State Board of Health of this Commonwealth: —

"That, in order to retain the high standing of this locality in the future, as regards health, one of three things will have to be adopted, or the abandonment of the place as a residence for health is but a question of time: —

"1. A general system of drainage;

"2. Pure water from ponds, brought in for culinary purposes; or,

"3. Offal and refuse of all kinds must be kept from contact with the earth, so far as possible. The Board look with favor upon the last proposition, and trust, if fully carried out, it will prove efficacious, and at a very small expense compared with the cost of the others. The Board have therefore adopted, and publish, the following additional regulations: —

"No privy, water-closet, or cesspool, not having a water-tight vault to convey the contents to its proper reservoir, will be permitted upon the premises of Oak Bluffs, Martha's Vineyard Camp-Ground, or Vineyard Highlands: Provided, however, that earth-privies or closets may be used, when dry earth or coal-ashes is daily added to the deposit in sufficient quantities to absorb all moisture, and the entire contents of privy-vaults removed at least once in two weeks.

"No vault shall open into any ditch, stream, or pond within the described premises.

"A violation of the above regulations will subject the person or persons so offending to a fine of one hundred dollars."

None of these regulations have been enforced, although continually urged upon the community; and the state of the soil and ground-water is constantly becoming more dangerous. It should be thoroughly borne in mind, that the "season" is very short, and that many of the visitors in the camping-ground remain there for only a few days; and that the comparatively "good health of the settlement" may arise, in part, from the fact that it would be difficult to trace cases of illness among the scattering visitors, if they occurred. Most of the foul matter disposed of underground is at such a depth in cesspools that it cannot properly oxidize and become innocuous, but, being held in mechanical suspension, is liable at almost any moment, either from further deposits or heavy continuous rains, to contaminate a majority of the wells in the village. The shallow privies are less dangerous to the wells, but contaminate the air more.

It must not be taken for granted that this condition of things is confined to Martha's Vineyard alone, although, perhaps, as flagrant instances of want of care have occurred there as in any part of the Commonwealth.

Visits to various seaside resorts of a similar character, on both North and South Shores, show little change for the better. Many individual cases are worse, on account of ledge, or clay subsoil, that either carry the filth on seams or cleavage planes, at times more than one hundred feet, or

hold every thing mechanically suspended but a short distance below the surface of the ground, only to rise to the surface again, and create nuisances, after every heavy rain that saturates the soil.

The following remarks on the wells are by the secretary of the State Board of Health, Lunacy, and Charity: —

"In order to justly appreciate the value of the results of chemical examinations of water for drinking-purposes, it is necessary to know something of its origin. Pond-water, for instance, may contain a large amount of ammonia and albuminoid ammonia, due to vegetable substances, which in most cases would be a pretty certain indication, in the same quantity, if found in a well-water, of impurity due to excrement; and by chemistry alone, unfortunately, it is possible to discriminate between the two only to a very limited extent. The amount of chlorine, too, which is safe in wells near the sea, would almost surely indicate contamination in the interior of the State; but this contamination may be due to urine, or kitchen-slops containing common salt, &c. Again, the total amount of inorganic matter naturally found in limestone regions is enormously greater than where granite prevails. In surface wells, nitrates and nitrites would be generally evidence of the presence of filth, partly or fully oxidized, or even again de-oxidized by oxidizing more filth.

"It is desirable first for each locality to ascertain the quality of normal wells, free from contamination, and to compare suspected wells with that standard, always remembering that a certain range is within the bounds of possibility in unpolluted wells. If possible, it is also useful to make a number of determinations of the same well, to ascertain how much its water changes from time to time, unless the question of pollution is a very clear one.

"By comparing the results of chemical examinations with inspections of each locality, it appears that: —

"No. 1 was by the first examination not objectionable, although the later increase in the amount of total solids and chlorine indicated impurities from a source which, considering the very small amount of nitrates and ammonia found, suggests the idea of kitchen-slops, rather than excrement, but which may have been from natural sources in the soil, or even indicate a slight excrement contamination.

"No. 2 was very pure water.

"No. 3 cannot be really objected to, from the chemist's point of view, although the nearness of possible sources of contamination makes one doubtful whether all the increase in chlorine, solids, and nitrates over No. 2 is due to natural causes and greater proximity to the sea, or to filth.

"No. 4 must be regarded with suspicion.

"No. 5 was very bad until the well was driven deeper, when it improved for a while, from June 21 to the examination made June 27. The examinations made again, July 11 and 16, showed that the water

had become dangerously polluted again. We are informed that the well was driven still deeper; and the later examinations revealed no results which would place the water among those fairly termed dangerous. It was hoped that subsequent analyses might be made, in order to ascertain whether the improvement continued; but the owner refused to allow a sample of the water to be taken. Upon the analysis of July 11, which, with the examination dated June 27, was made under the direction of the proprietor of the well, an opinion was given, that the water 'is a fair one for domestic use, and free from injurious matters;' but that view was not sustained by the secretary of the State Board of Health, Lunacy, and Charity, nor by the chemists employed by the Board.

"No. 6 could not at first be fairly objected to. The variations in the amount of chlorine may, or may not, indicate any thing.

"No. 7 was found to be suspicious, probably from excrement, and grew worse.

"No. 8 was also thought at least suspicious, and, as it became worse, was declared unsafe for use.

"No. 9 was, of course, very bad indeed, until removed to a point thought to be safe, as the first examination showed it likely to be; but its present surroundings suggest danger in the future.

"No. 10, too, was condemned.

"Nos. 11, 12, and 13 were not seriously objected to.

"No. 14, in Edgartown, was not found to be unsafe.

"No. 15 was very bad, and is only five rods from No. 5.

"No. 16 cannot be objected to in chemical results.

"No. 17 showed a rather large amount of chlorine, but the other ingredients were not necessarily excessive: it could not be strongly objected to.

"No. 18 showed an amount of nitrates which would be considered large, as compared with some others, but it does not necessarily follow that it is polluted seriously.

"No. 19 was bad.

"No. 20 was probably not at all contaminated.

"No. 21 was suspicious; a death from typhoid-fever was laid to it in 1878.

"No. 22. Very bad.

"No. 23. Bad and condemned.

"No. 24. Possibly slightly contaminated by kitchen-slops.

"No. 25. Bad, and not far from 5 and 15.

"No. 26 had a considerable amount of nitrates and probably an excess of chlorine.

"No. 27. Perhaps contaminated.

"No. 28. The amount of chlorine probably indicates pollution.

"No. 41. Unsafe.

"No. 42. Unsafe.

"Commonly speaking, there was no bad taste observed, even in the polluted waters: it was noticed, however, in the case of 9 and 15.

"Of course it is not yet known how wide a range in the amount of chlorine is consistent with natural causes, nor, indeed, how much varia-

tion may be allowable in the amount of the other ingredients. Above all, we are still ignorant how far it is possible to drink human excrement without incurring disease, —to what degree of dilution or oxidation it is necessary to have it reduced, exactly wherein lies the danger from the poison of specific diseases, and precisely when and where the danger begins. That polluted drinking-water is often used without apparent harm, is well known: that there is *always a risk*, no matter how great or how small, in drinking it, is now demonstrated. Chemical examination, too, may not reveal any indication of a very slight but dangerous impurity, and a rain-storm or an extra accumulation of filth or other causes may produce very manifest contamination of a well when its existence was not previously suspected.

"*The only safe rule* is to have wells so situated that they *cannot be polluted;* or, to put the proposition in another form, to so arrange privies, cesspools, &c., that they *cannot contaminate the sources of water-supply.* If this were done in Martha's Vineyard, and if the previously given directions of the local board of health were carried out, with tight cesspools, emptied by some of the odorless excavators for the liquid refuse, and with proper removal of garbage and swill, all reasonable requirements of health and decency might be readily filled."

The reader's attention is now directed to a different class of houses, — the larger hotels and boarding-houses of the North Shore.

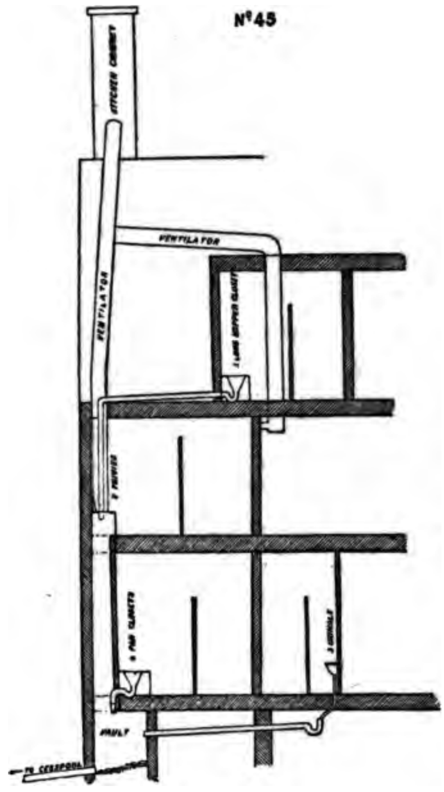
No. 43. A boarding-house accommodating twenty guests. Bath-room, water-closet, set basins in chambers and on ground floor. Sewer-air was noticeable in the front hall. Peppermint introduced in one of the set basins comes up strongly, after the lapse of a few minutes, through *all the other set basins in the house.* The average length of untrapped lead waste from each basin was *forty-nine feet!* It is the habit to pour chamber-slops through the basins. Separate soil-pipe of sheet-lead for the use of bath-room and water-closet. A hole corroded in the soil-pipe, just below water-closet, over the kitchen ceiling, large enough to insert four fingers. A portion of the water-closet sewage runs out on the back side of the plastering every time the closet is used. The proprietor states that he has mended the roof of the L several times, but it still leaks, he thinks in some way around the tin flashing! The sewage all runs to a leaching cesspool outside the house. Public water-supply. One case of sore throat in the house the past summer. Character of the subsoil, gravelly.

No. 44. Hotel accommodating one hundred and seventy-five guests. At this house there is a combination of the dry-

conservation and water-carriage systems. Character of the soil, hard-pan. On the third story of the house is a set of three pan-closets, delivering into cast-iron soil-pipe. Kitchen and china-closet sinks run to same. S-traps all unventilated. Soil-pipe at upper end enters kitchen-chimney. Outside the house, on the second story, a slop-hopper connects by a square box-drain with a sunken hogshead, for chamber-slops. Hogshead overflow connects with soil-pipe outside the house by a four-inch vitrified pipe. An irrigation-field, one hundred and eleven feet by forty, receives all the soil-pipe matter. Surface irrigation. It is sixty feet from well to cesspool, twenty-one feet to nearest point of drain. Joints of drain made tight (?) with blue-clay luting. Peppermint in soil-pipe showed one very minute leak between second and third floors. Outside the house is a two-story privy, containing twelve sections. Has been in use fifteen years. Hard-pan clay bottom. Privies are used daily during the summer by probably sixty persons. Dry earth is scattered over deposits once, sometimes twice, every day. Vault had not been emptied at the time of visit, but was as sweet as any apartment could be. Urinal overhead not quite so good: needs leading and a roof. The house is very neatly kept, and there is no appearance of neglect in any portion of it. There has been no sickness in the house, and no smell except occasionally from the slop-hopper. Passers-by complain sometimes of the irrigation-field, but if put underground no fault would be found.

No. 45. A popular summer hotel accommodating one hundred and fifty people. All sinks, privies, water-closets, and urinals are in the L, separated from the house proper. On the third story are three long hopper closets, delivering into four-inch cast-iron pipe; also a slop-hopper running to the water-closet trap. *Soil-pipe delivers into privy-vault on second story.* On the second story underneath, and a little to the rear of the closets on the third story, is a set of four privies. Vault runs up two stories; a ten-inch ventilation-pipe of tin connects the top of the vault with the kitchen-chimney. On first story are four pan water-closets, delivering also into privy-vault mentioned above. Three urinals deliver (with open joint) into a four-inch cast-iron trap, which in turn empties into vault. Vault presumed to be tight. Overflow

from vault to tight cesspool, which in turn overflows as shown in plate. Pantry sinks with unventilated S-trap. The laundry has a large hopper, where a whole tub of water can be turned in at once, unventilated and uncovered. The plate shows the various wastes as they come from the house and cesspool. The material, as nearly as can be described, is galvanized-iron stove-funnelling, slip joints, made tight (?) with a daubing of lime-mortar. As a fact, none of them are tight. The delivery is eventually into a square wooden box-drain, through a cast-iron S-trap, and the material all runs to mean water. Peppermint put into the hopper closets seemed to diffuse itself all over that portion of the house in a very short time. The outside arrangements are all to be changed this winter, and cast-iron substituted therefor. There has never been a serious case of illness in the house during sixteen years. A public water-supply. The entire separation of the conveniences from the main house seems to be the only reason why sickness has not taken place, none other. The house is neatly kept, and no effort seems to be spared to make guests comfortable and satisfied. It is an unsafe arrangement, however, from beginning to end.



No. 46. A cottage connected with a hotel. Two water-closets, two set tubs, three bowls, bath-tub, and sink comprise the plumbing. A good cast-iron soil-pipe properly put together. The sink is not much used, and is in a chamber;

is connected with soil-pipe by an unventilated S-trap that siphons. The bowls have untrapped wastes. Every thing goes to the two water-closet traps. Ventilator from cesspool

OUTSIDE DRAINAGE ARRANGEMENTS OF HOTEL ON THE NORTH SHORE.

connects with one of the hollow wooden piazza-posts. The boarders have complained of the smell, that at times is sickening. It seems as if the cesspool ventilated directly into room with sink and unventilated S-trap.

General Remarks.

These investigations were made at some of the most prominent summer resorts in the Commonwealth; and enough has been ascertained to warrant the formulation of a definite opinion in regard to existing practices. And here it is in order to state that while in some cases a lamentable want of neatness was painfully apparent, yet, on the whole, the outside appearance of things was such as would be likely to meet the full approval of most people, were it not for certain unmistakable odors or signs of danger that no reasoning man could put roughly aside as inappreciable to detriment. The writer is inclined to believe that insufficient sanitary regulations prevail among householders rather from lack of knowledge than through mere heedlessness; and this idea finds support from the fact that *all* hotel-keepers express

a desire to perfect their arrangements, if only some feasible way be pointed out. Local boards of health but half perform their intended duty when they simply prohibit the further continuance of a nuisance, but fail to prescribe the best remedy for each particular case.

The changes needed to produce the best results are not so extremely radical as very many readers may imagine. A majority of houses, both public and private, must for many years yet continue to use dry conservation, as being the simplest, and giving the least trouble. This means, stating it plainly, the cesspool and privy, the former being used for kitchen and chamber slops. The cesspool is far the more dangerous of the two, and should always be made water tight, and emptied at regular intervals, or, better still, *removed entirely*, and a flush-tank substituted, with irrigation for the sewage.

Flush-tanks are self-emptying, tight cesspools, small in size, and made automatic by means of a siphon or siphons. The delivery is through an impervious pipe into a set of red earthen or white stone tile, laid with open joints, some ten inches below the surface of the ground. This causes a uniform distribution of the matter below the surface, yet not so far below as to prevent its absorption, to a very considerable extent, by plant-life on the surface, and oxidation of its products by partial contact with the air. Till recently ordinary tight cesspools were used with overflows in the usual way, either to the surface, to another cesspool, or to deeply laid subsoil pipes. This process was only used to give greater leaching surface than could be obtained by the one cesspool. The result is commonly what might be expected. The soil becomes thoroughly saturated with filth, and not having opportunity to cleanse itself becomes worse and worse. During the past season a large leaching cesspool, doing duty for a medium-sized summer hotel, became, with the soil adjacent, entirely saturated with sewage. Situated on a steep bank, the filth began to ooze out, till a heavy soaking rain so loosened the turf, that a section of the ground in the immediate vicinity of the cesspool fell away from it, disclosing to view a mass of filth that cannot be described. The stench arising from it was simply horrible. The cesspool had never been cleaned out, and had been used for several years.

It has yet to be proved whether the flush-tank, delivering so near the surface (ten inches), will answer satisfactorily in our climate; whether it will not freeze up and be troublesome in winter, and whether it can be made to work as well in one soil as another, as is claimed; also whether the pipes must not be cleaned annually. These, however, are considerations not within the province of this paper. The underlying principle is undoubtedly far superior to the ordinary cesspool, and may be quite generally substituted for summer houses within the next few years.

Privies should *always* be tight. Dry earth or ashes should be added daily, in sufficient quantities to absorb all moisture and prevent offensive smells; and they should be entirely cleaned out at certain frequent and definite periods. It may be well to state here that disinfectants merely retard, but do not prevent, decomposition.

Water-carriage includes what are known as all the "modern conveniences." Every thing, as has been said before, runs finally either to some water-course, pond, the sea, or the leaching cesspool, if not used as a fertilizer. Under the same conditions, unless there is a public water-supply and sewerage, the disposal of waste by the water-carriage system is a much more complex problem to solve, than by dry conservation. The quantity of foul matter being the same, it is diluted many times, and requires just so much more leaching surface to diffuse itself over; and wells and cisterns are more apt to become contaminated by infiltration. In addition to this, defective plumbing is frequently the source of very much trouble; and, unless care is taken, house-drains may act as direct ventilation for the cesspools, in a manner far different from what was intended. Ventilation of cesspools directly through the house-plumbing has been recommended. The writer dissents entirely from this method. A proper ventilation-pipe outside a building is vastly safer.

Public water is a doubtful benefit unless sewers are also provided to carry off the waste waters; and a number of our summer resorts are experiencing much difficulty on this account at the present time.

In regard to plumbing, it may be briefly stated that all waste-pipes within a building in every part should be of metal, and, as far as possible, cast-iron. No vitrified or

cement pipe, brick or stone drain, slate, &c., should be permitted in any case. The main waste should be of cast-iron, with double-calked lead joints bevelled: no putty, elastic cement, red lead, canvas, paper, or any such of the numberless materials found in joints, should be tolerated. Pipes should be carried through the roof higher than the tops of the chimneys, or at a point remote from them. They should be well ventilated, and provided against siphoning of any of the traps connected with them. The whole house-drainage system should be separated from the sewer by an efficient trap. The iron portion of the drain should also extend at least five feet outside the cellar walls. All slop-sinks, bowls, bath-tubs, and sink-wastes should join the main waste as quickly as possible after leaving their initial point. Sink-wastes and the like are usually of lead pipe. In making joints between lead and iron, almost every one met with is poorly done and leaky. A brass ferrule, calked to the iron and soldered to the lead, is the only proper joint.

Slime and grease from sinks, bowls, &c., very soon coat and clog small wastes; while, if introduced into the main waste-pipe, the alkalies from the water-closet have a constant tendency to cut out all such grease.

As much as possible of the soil-pipes, drains, &c., within the house, should be accessible for frequent and thorough inspection; and it would be well as an additional precaution to have them covered with a sensitive white paint.

It is still an open question among sanitarians, whether ventilated S-traps for sinks, bowls, &c., or barricade-traps, are preferable. S-traps if unventilated are in many cases almost worthless, as they have a strong tendency to be siphoned. Valve and barricade traps are presumed to be bad in principle, as being filth receptacles, but the best of them cannot be forced by any back pressure, neither can they be siphoned; and where there is any question about adequate ventilation, or lack of proper knowledge of ventilation, barricade-traps seem perhaps the wisest to adopt.

It is quite generally known that leaky house-drains are commonly detected by using peppermint, though just how this is done is not so thoroughly understood. Peppermint

is not indispensable. Any of the volatile essential oils will answer as well; but, from its cheapness, peppermint is usually employed. It is put up in small vials for the purpose, one vial containing sufficient to test one line of pipe. First, remove all casing there may be around the pipes throughout the building. Stuff tow, paper, rags, or any convenient article, as closely as may be around the pipes where they pass from one story to another, to prevent the smell from following the pipe upward. If possible, station a person on every floor, furnished with chalk or red pencil, to mark the actual location of any detected smell. If the main drain (soil-pipe) extends through the roof, station the operator at that point, with vial and two pails of hot water. Everybody being in position, let the operator pour down the peppermint, and, as soon after as possible, both pails of water, taking care not to spill peppermint on his clothes or on the floor or roof. The observers on every floor should now try to detect any smell they may be able to, and mark any such places with chalk, so that they can be examined in detail at leisure. This is the entire operation. The person on the roof must on no account for at least ten minutes leave his position; for he will surely bring the smell with him to a greater or less extent, and leaks may not all be detected in less than that time. If the soil-pipe does not extend to the roof as it should, run the peppermint through the upper water-closet or set bowl. If there be more than one set of pipes, and the first is found leaky, they must be tested on different days, one at a time, as it is impossible to get all the smell out of a house in less time. The cost of the peppermint is two dollars per dozen vials. Length of time required to thoroughly inspect a building, from one to five hours, depending on the complexity of the pipe arrangement.

Summer hotels and country boarding-houses are never so thoroughly well built or maintained as buildings used the year round: it is unreasonable to expect it. Their season as a rule being short, it is impossible for them to be so without charging prices that no one would think of paying. Cheaply put up structures usually include cheap (dangerous) plumbing and general sanitary arrangements; and though summer dwellings can stand a second quality of such work, and yet,

from much greater circulation of fresh air through windows and doors, maintain perhaps a good standard of health, it is better to have plumbing, whatever it may be, in a measure removed from the sleeping portions of the houses at least. Let all arrangements be as as simple as possible, *tight*, and easy of access for inspection.

Architects have it in their power to do more towards sanitary improvement, than perhaps any other class of professional men. Unfortunately few of them, as a rule, take that interest in doing so that they should. Does any one of the profession in Massachusetts put a clause in specifications to the effect that all plumbing shall be subject to the peppermint or any other effectual test before being accepted? or if they do is it enforced? Is there any other way of thoroughly proving new work?

NOTE.

Since the above report was written, "Cottage City" has been separated from Edgartown by act of the Legislature, and a local Board of Health has been elected. This Board has adopted a code of sanitary regulations, and after conference with Messrs. Davis and Webster, of the Health Department of the State Board of Health, Lunacy, and Charity, and the Secretary of the Board, manifested a disposition to adopt their suggestions (see pp. xii and 190), and to carry them out with due energy. If this be done promptly, the difficulties mentioned above may be remedied, and a high reputation as a health-resort may be preserved.

SUGGESTIONS ON SEWERAGE.

BY

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SUGGESTIONS ON SEWERAGE.

EXPLANATION OF TERMS USED.

Sewerage. — The removal of certain kinds of filth by water-carriage.

Sewer. — A conduit through which filth is removed by flowing water.

Sewage. — The combined water and waste matters found in sewers.

Main Sewer. — The largest sewer of a connected system for draining a limited district.

Lateral Sewer. — Also called branch or sub-main sewer; one which receives the flow from pipe-sewers, and itself empties into a main.

Pipe Sewer. — One made of clay or cement pipe.

Intercepting Sewer. — A large sewer which conveys the sewage from several main sewers to an outlet.

Drain. — A house-drain ; a small conduit for conveying sewage from a house or group of houses to a street-sewer. Some writers restrict its meaning to a carrier of pure water, as opposed to a sewer. In law "main drain" and "common sewer" are synonymous terms.

Drain-pipe. — Pipe made of burnt clay or of cement, used for sewers and house-drains.

Sewer-gas. — More properly, sewer-air. The atmosphere of sewers, principally pure air with a varying admixture of gases and vapors, some well known, and some obscure, the products of decomposition. The occasional presence of minute solid particles, with animal and vegetable germs and spores, is suspected.

Sludge. — Solid organic and inorganic matters deposited by sewage, existing in the form of black putrescent mud.

Man-hole. — A structure connecting a sewer with the surface of the ground, through which it can be entered.

Catch-basin. — Also called catch-pit and gully. A receptacle through which rain-water flows to a sewer, and by which sand and gravel are intercepted.

Sump. — A pit in the bottom of a shaft or man-hole.

Tide-gates. — Gates or valves at the outlets of sewers, which close as the tide rises, and exclude it.

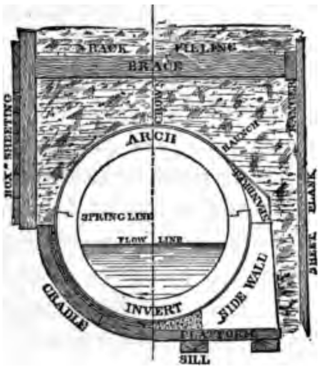


Fig. 1.

Trap. — Short for stench-trap. Any arrangement for preventing the circulation of sewer-air. When it consists of a depression, filled with water, in a pipe, the portion of water which prevents the passage of air is called the "seal" of the trap.

Detritus. — Fine particles worn from the surfaces of streets by attrition.

Datum-plane. — An assumed horizontal plane under a district, to which all elevations are referred.

Plant. — The tools and apparatus by which a business or work is carried on. A sewer-contractor's plant consists of engines, derricks, spades, &c.

The principal parts of a sewer, with their names, are given in Fig. 1.

1. In devising or executing a system of sewerage, it is always best to seek the advice of an expert in such work, who, familiar with approved practice and methods, can adapt them to the special conditions of the place. The general requirements of efficient sewerage are, however, easily understood, and on account of their importance should be learned by all, especially by those interested in sanitary science. Many of the details of construction are simple, and can be executed by any one of ordinary skill and judgment.

2. In devising a sewerage system, the first step is to determine the exact area which is to be tributary to it. It is not necessary, and seldom wise, to build the system as a whole at one time; but the entire extent of territory which may ultimately connect with it must be determined, in order that the sewers first built may be adapted to receive the flow from those constructed later. This point requires careful consideration. If too large an area is included, the sewers will be proportionally large and expensive, and, because too large for the amount of sewage first carried in them, will be liable to have deposits and to require cleaning. If too small an area is allowed for, any attempt to add to it will overload the system, and new districts must be reached at great cost by new and long sewers.

3. The considerations which govern this question are the prospective increase in population, and its probable direction of growth. The present reasonable efficiency of sewers must on no account be sacrificed to future needs, and the interest on money saved at first may be considered applicable to an enhanced cost of providing for future contingencies. If the district to be sewered is surrounded by high land draining towards it, provision must be made for taking or for diverting the surface-water from outside the district. Sewers too large for present needs may be kept clean by periodical flushing from water-courses, from tanks, or by means of movable dams in the sewers. Sewers too small for future needs may finally be made to do double duty by discharging, at intervals along their length, a portion of their storm-waters into water-courses.

4. The second step is to decide upon a method of disposing of the sewage, whether to put it into water or upon land,

and the position of the outlet. No method of utilizing sewage has yet been devised which repays the cost of treatment. Profit is out of the question, and the cheapest *harmless* way of getting rid of it should be adopted.

5. Towns upon the sea-coast, estuaries, or tidal rivers, may properly turn their sewage into salt water, provided it is carried to a distance by currents, and does not return to form deposits of sludge upon flats near habitations. A sewer should not discharge off a beach or straight line of sea-coast, unless a current sets strongly in a direction parallel to it.

6. To ascertain whether a point is suitable for discharge, observations on the currents at that point should be made by means of floats. The mean direction and velocity of the body of the current, and not of some thread of it, or of its surface, should be determined. Figs. 2 and 3 show suitable floats for this purpose. They should be followed in boats for from six to thirty hours, and, should they ground in shoal water, may be taken up, and shorter ones substituted. From any point a number of trials should be made, at different stages of the tide, and also under the least favorable conditions, which will be when a high course of spring-tides is working into a lower course of neap-tides.

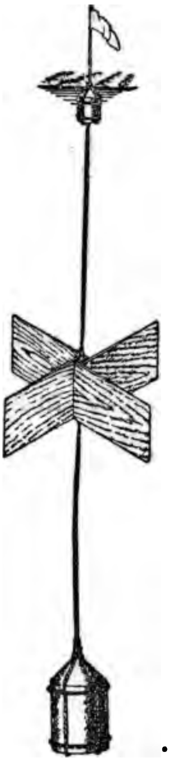


Fig. 2.

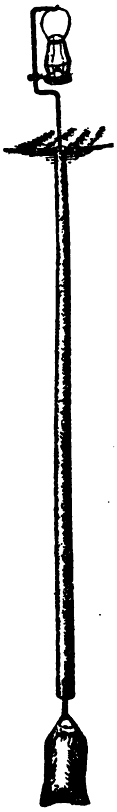


Fig. 3.

7. Places may be found suitable for a discharge on the early ebb-tide, but at no other time. It will then be possible

to collect the sewage accumulating during the flood and late ebb tides in a reservoir, out of which it may be emptied at the proper time. Where any portion of a town-site is too low to be drained at high tide, the sewage contributed by that portion should be raised by pumping. Occasionally, under the advice of an expert, it may be feasible to collect the sewage from low districts into tanks or large cesspools, whence it can be let out at low tide.

8. The general practice of allowing the street-sewers to act as such cesspools, by providing them with gates at their

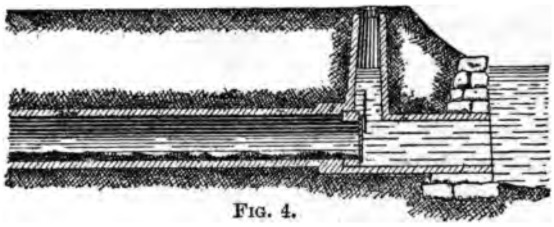


FIG. 4.

outlets to shut out the tide, and shut in the sewage, is bad. An attempt is made to illustrate the evils resulting from such a course, by Figs. 4 and 5. In Fig. 4 a sewer, tide-locked at high water, with its gate closed, is filling with sewage; and, there being no current in it, deposits of sludge are accumulating on its bottom. The sewer-gas, arising from previous deposits, is displaced, and forced to seek an outlet through man-holes, catch-basins, and house-pipes. In Fig. 5 the sewage discharged at low water meets the incoming tide, and, as indicated by the broken lines, is returned upon the neighboring shore.

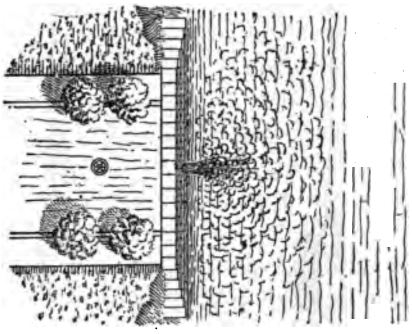


FIG. 5.

9. A small amount of sewage may be discharged into a fresh-water lake or pond, provided the proportion of sewage to pure water is so slight as to cause no appreciable pollution. But it should be remembered that subsequent growth

of population, and corresponding increase in the amount of sewage, may in the future necessitate an entire abandonment of such a system; and, before incurring so great a risk, competent advice should be taken.

10. Rivers and smaller streams may sometimes be used to receive sewage, but should not be to such an extent as to pollute their waters, if these may be needed for domestic purposes. The admixture of sewage which would be held to constitute pollution cannot be exactly stated, but may be as slight as one part of sewage to one hundred of pure water. As there are legal restrictions controlling such a method of disposition, the laws should be carefully consulted before incurring expense.

It is usually best to convey sewage, by an intercepting sewer, to a single point of discharge below the town, and to place the outlet well within the main current of the stream. If the sewer itself be higher than the surface of the stream, its immediate outlet may be under water, and the sewage will discharge as freely as in air.

11. Where crude sewage would cause pollution, but it is not necessary to do more than clarify it, it can be sufficiently cleansed by one of several chemical processes; all of which are, however, somewhat costly. This plan has been adopted by some cities and towns in England, and might prove expedient here for manufactories furnishing a comparatively small quantity of concentrated sewage.

12. Another way of so far purifying sewage that it may be admitted into a stream, is by filtration through natural soil, or prepared filter-beds. The area of land required is small, but it must be of a very light and porous character. In England a single acre, suitably prepared to act as a filter, has disposed of even two hundred thousand gallons of dilute sewage daily.

13. Where sewage cannot be discharged into water, the most common method of treatment is by surface-irrigation; and a sanitary engineer should be employed to prepare a plan for such disposition of it, suited to the conditions of the place. The land to be irrigated should be somewhat remote from habitations, and, to avoid pumping, should, if practicable, be so low that the sewage may flow to it by gravity. A light, loamy soil is best suited for irrigation. The area required

will vary with the character of the land, the nature o: the sewage, the amount of rain-fall, the climate, &c. Foı a rough approximation, from one and one-half to severa: thousand gallons of sewage daily may be distributed oveı one acre. An even surface is desirable; but, if moderately uneven or undulating, it will answer.

Sewage can be disposed of in this way at all seasons oi the year. The land may be cultivated; but, unless the conditions are unusually favorable, the crops will not repay the cost of maintenance of the farm. From extended English experience on many sewage farms the following general rules have been established.

Managing a sewage farm differs in many respects from ordinary farming. Special methods of treating both the land and the crops are required. Under proper treatment, however, any land will be improved by sewage irrigation, and will neither be rendered foul nor be exhausted. The sewage must be applied evenly at regulated intervals both of space and time, and always while fresh; that is, before it has begun to putrefy; otherwise an effluvium will arise from the ground. If applied promptly as it comes from the sewers, there can be no just grounds for complaint on this account. Where nuisances have been created they have been caused either by the use of old and putrid sewage, which has stagnated in too large tanks or open carriers, or by a failure to cleanse these receptacles when they had become foul through settlings from the sewage.

Irrigation works of this kind cannot be too simple in their construction. All ordinary conduits or carriers, for distributing the sewage, may be open ditches dug by the spade or plough, and the smaller ones, which follow the contours of the surface, may be mere gutters not intended to be permanent.

The most profitable crop to cultivate has usually been found to be Italian rye-grass, which may be grown for two years. After this the land should be ploughed over, the smaller carriers being thus obliterated, and a root-crop cultivated for one year, when the field may be again laid down for a second course of Italian grass, and so on.

The grass is used to best advantage immediately after cutting, and is most profitably applied by feeding it to stall-fed dairy cows. The grass grows so rapidly, and such a heavy

crop is harvested, that, to prevent waste and failure, a special market for it, near at hand, is essential. Sewage farming has been pronounced a failure, in some places remote from markets, solely because the farms were so productive that the grass spoiled before it could be used. Dairy products, such as milk, butter, and cheese, are, however, staple commodities, for which there is a constant demand; so that with judicious management there should be no difficulty in disposing of the entire product of any farm, no matter how large.

14. The point of discharge being fixed, the whole system may be elaborated, and the routes of the sewers be decided on. For this purpose, as also for the remodelling of a system partially constructed, an accurate plan of the locality is essential. It should be drawn on a scale not smaller than four hundred feet to an inch, and should show water-courses, drainage-areas, streets, alleys, existing sewers, and also indicate groups of dwellings. The elevation of the streets, above some fixed plane of reference, should be marked upon the plan, at every few feet change of height. This base or datum plane will usually be the one already established at the place by local surveyors; or, if there is none already, it may correspond to low water, either of the sea, or the pond or stream into which the sewage is to flow, and should always be lower than any of the works which may eventually be built. The plan will be more useful if points of equal height be joined by contour-lines as shown on the specimen plan, Plate I. Such a plan shows at a glance the general routes which must be followed by the sewers; and on it the system may be mapped out.

15. As sewers are placed below the surfaces of the streets, and a portion of the soil must be excavated to receive them, it is evident that the character of the ground in which they are to rest forms an important element in their stability and cost. It also affects the choice of route, and should be ascertained with care before deciding upon the latter. This knowledge may be obtained with sufficient accuracy by means of test-borings made with boring-rods similar to those shown in Plate II. The apparatus, as will be seen, is very simple, and consists of an auger, Fig. 1, with jointed stem, Fig. 2, and appliances for turning and raising it. The

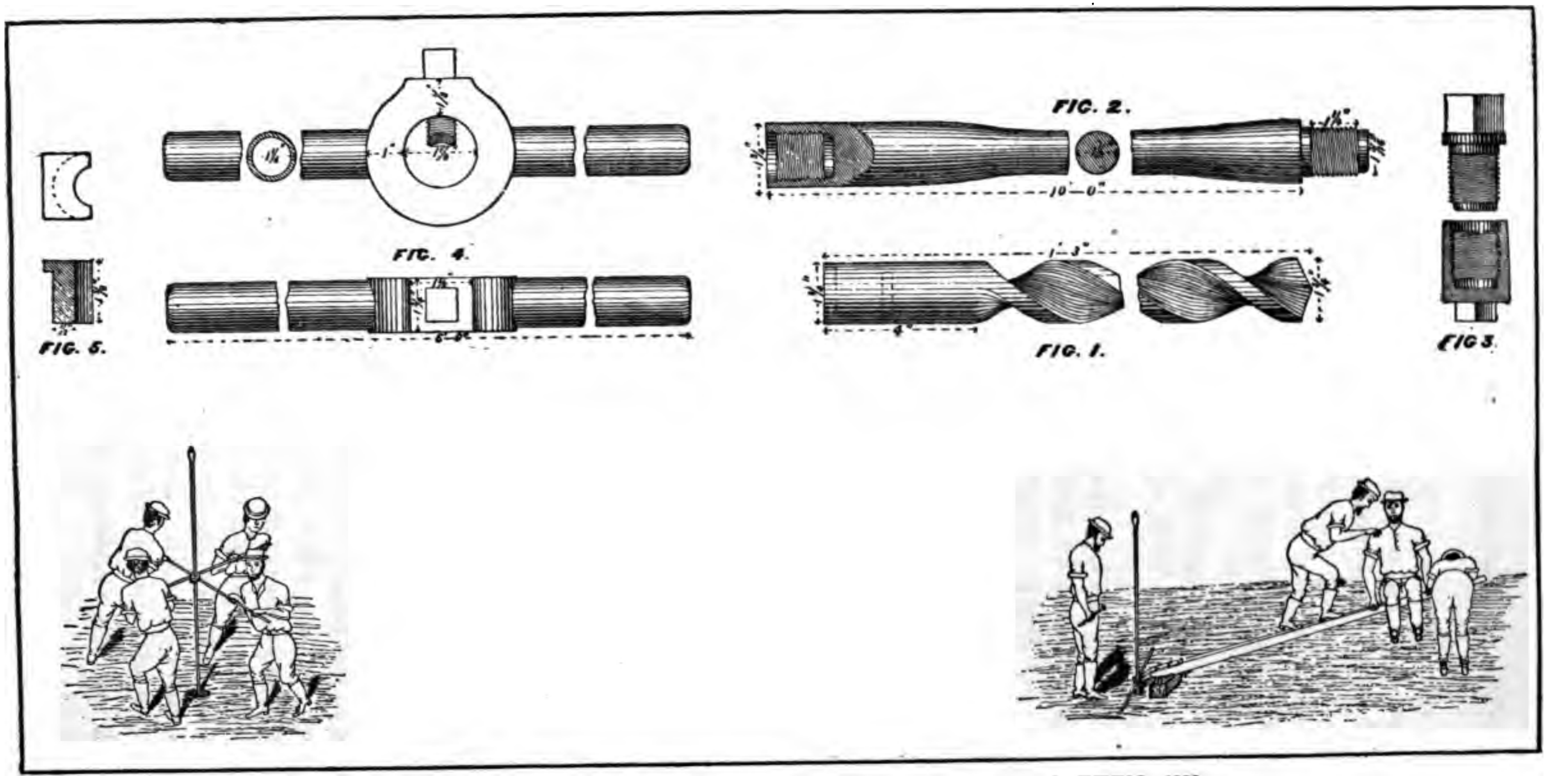


PLATE II.—LIGHT BORING TOOLS, AND MANNER OF USING THEM, 1880.

auger, resembling a stout wood-auger, is forged from cast steel, twisted and hardened at a dull blue heat. The screw ends of the rods and auger should fit with great nicety, and when not in use should be protected by caps and plugs, Fig. 3. The handles, Fig. 4, for turning the rods, are of gas-pipe, welded to solid rings, and are made fast by hardened steel set-screws, and chocks, Fig. 5; the former being concave at their faces so as to bite into the rod.

The method of making a boring, and of pulling up the rods, is sufficiently indicated in the sketch. The nature of the ground met with is known by its different jarring effects upon the rod. These will be understood after a little practice; but at first, and always in case of doubt, the rod should be raised frequently, and the earth last penetrated, which will be found packed in the grooves of the auger, examined by inspection.

The first cost of apparatus, with fifty feet of rods, will be about one hundred dollars; a foreman and four laborers constitute a full gang of operators; if paid at the rates of three dollars and one dollar and a half a day, the daily running expenses will be about nine dollars; one hundred feet of borings is a fair day's work in ordinary ground. Where it is tolerably uniform, the borings may be three or four hundred feet apart; but where the ground is changeable, or rock is found or suspected, they should be much nearer.

16. Having the contours of the surface of the region, the localities of present and prospective population, and the character of the soil on different lines, the choice of routes for the sewers is a matter of judgment, for which few rules can be given. The larger main sewers will usually follow lines of low elevation near the centre of natural drainage areas. Smaller branch sewers must go where there are streets, and dwellings to be accommodated.

Natural water-courses should not be used as sewers. Their diminished areas and slow velocities in time of drought, and, still more, the shapes and character of their bottoms, are sure to produce deposits of sludge, which will be offensive, and may be dangerous. The evil will only be aggravated by building a cover over them.

17. Such channels may, however, form valuable adjuncts to sewers, by removing a large proportion of the storm-

water of the district; either receiving it direct as it flows over the ground, or taking the surplus from the sewers through overflow outlets. They may therefore with advantage be straightened, cleaned, deepened, and embanked.

18. When local conditions require it, a sewer may be built on supports above ground, as across a ravine; through a hill, by tunnelling; under water, by means of coffer-dams or pipes; and even may cross under a river or other obstacle by means of an inverted siphon.

There are objections to this mode of construction; but, if carefully designed, it will not affect the efficiency of the system. Being under pressure, the siphon must be of extra strength, often of iron. Running full at all times, even when the sewers on either side are comparatively empty, it must be much smaller than the latter, to have a cleansing velocity of flow; and, to discharge as much as the sewer brings to it, the farther end of the siphon must be considerably lower than the other.

19. In designing even a single sewer, it is essential to bear in mind the whole system, and the relation to it of the work projected. The imagination may be assisted by analogies. One such is found in a tree, with its trunk, limbs, branches, and twigs diminishing gradually in size as they rise upwards from the main stem. Animal cells, fed by arteries, and returning vitiated blood by the veins to the pumping-station at the heart, afford a very perfect analogy to the houses of a city, into and from which flows pure and contaminated water, through water-pipes and drains.

20. Drains and sewers should fall continuously towards their outlets, and in every case should join sewers somewhat larger than themselves. A four-inch pipe, for instance, should discharge into a six-inch one, a ten-inch into a twelve-inch, a sewer two feet in diameter into one three feet, and so on. These rules seem so obvious, and so universally accepted, as to make any mention of them superfluous. Yet they are often neglected, and portions of sewer-systems are frequently observed in our cities and towns constructed in direct violation of them. Fig. 6, for instance, shows an arrangement of street-sewers observed in one of the cities of this State. As will be noticed, the discharge from two sixteen-inch by eighteen-inch sewers is delivered into one eight-

inch pipe of barely one-tenth their capacity. The sewers are four feet lower than the pipe with which they connect, and are filled with back-water and sludge. Three cesspools are added, which produce additional sewer-gas. Such gross defects could probably be paralleled in many other places.

21. It is impossible to give exact rules for determining the sizes of sewers: the best one that can be offered is, to leave this to some one whose judgment has been trained by experience. The problem may, however, be stated, and also a few general principles governing its solution.

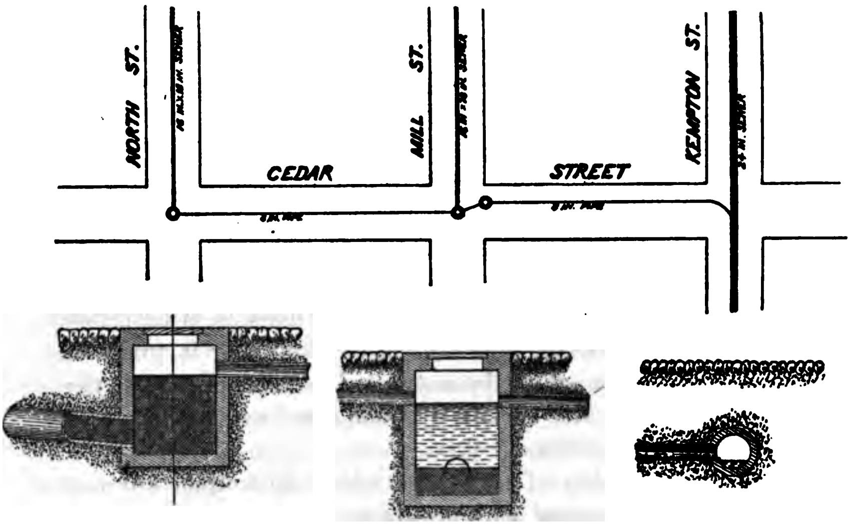


FIG. 6.

The size which a sewer must have depends upon the quantity of sewage which is to flow through it in a given time, and upon its inclination. Disregarding the latter factor for the present, it may be said that the sewage will consist of —

The water-supply of the district sewered;

Leakage from the soil into the sewers;

Rain-water during rain-storms:

All of which quantities are variables.

22. The water supply of cities and towns in Massachusetts varies greatly in amount, but for any given place can be ascertained, and also perhaps, with sufficiently approximate accuracy, the *prospective* supply, which is that for which provision must be made; so that, as regards main sewers, this portion of their contents is determined with comparative ease.

The difficulty increases with branch-sewers. One of them, for instance, may drain a district of five acres, on which, at first, there may be a dozen dwellings, containing seventy-five inhabitants: ten years later the same area may be covered with tenement-houses, and have a population of two hundred persons to each acre; or there may have been built on it a sugar-refinery, brewery, or other manufacturing establishment using one hundred thousand gallons of water a day.

All that can be done is to exercise judgment in deciding what will be the number and class of buildings on a district; then, from the average daily quantity of sewage, find how much may be expected per hour, minute, or second. But, since twice as much water is used at some hours as at others, this average amount for any given time must be doubled to give the maximum quantity to be discharged.

23. How much soil-water will leak into a sewer, depends upon how much water there is in the soil, and what precautions are taken for excluding it. Vitrified-pipe sewers, if well laid, leak very little: through brick ones, even if constructed with care, more or less water will soak; house-drains as usually built are almost sure to leak. Often it is desirable to lower the soil-water of a district by admitting it freely to the sewers. In some well-constructed systems of sewers the amount of soil-water carried by them has been estimated at one-tenth of the ordinary flow.

24. The quantity of rain-water which falls upon any district may be measured with accuracy. The most convenient way of stating it for sewerage calculations is in cubic feet per second; and, as rain-fall is usually measured in inches per hour, it is well to remember that one inch in depth per hour equals (very nearly) one cubic foot of water per second for each acre.

What would be called a heavy rain-storm rarely yields a quarter of an inch of water in one hour, but there are exceptional storms which give an inch or over in that time. Investigations have shown, however, that only a portion of what falls reaches the sewers. Part of the rest is absorbed by the soil, part is evaporated, and some of the remainder, which must be provided for, is delayed on its way to the street catch-basins, so that what falls in one hour may take two hours in reaching the sewers.

This loss and delay varies greatly with the condition of the surface of the district. If the latter is solidly built over, with rain-water carriers from the roofs joining house-drains, paved streets, and yards with gutters, the whole amount will be delivered almost as rapidly as it falls.

The common practice is to assume an inch an hour as the maximum quantity to be provided for, and that one-half of it must be carried by the sewers in the same time. For large districts and main sewers this provision is probably ample; but it must be modified in favor of smaller ones, especially where the flooding of cellars would cause great pecuniary damage.

25. If the original water-courses of a district have not been encroached upon, a solution of the difficulty is sometimes afforded, and consists in providing a great many waste-outlets, through which any surplus of storm-waters may escape from the sewers into the water-courses. The earliest portion of a rain which washes roofs, yards, and streets, becomes rather dirty; but usually sewage during a heavy rain is so diluted as to be inoffensive, and any amount that would escape at that time into an open channel would cause no nuisance.

26. Under competent advice it might be possible to construct a sewer system from which all rain-water should be excluded, the latter flowing off over the land as before. Such a system would be much cheaper than any other; but the town adopting it must, in return for the economy, be prepared to suffer the occasional flooding of streets and areas by rain, and to prevent continual attempts to introduce some of it surreptitiously into the sewers. Should a change be desired at a future day, it could only be accomplished by an entire rebuilding of the sewers, or the adoption of a costly and complex double system.

27. Should it be decided to design sewers of carrying capacity sufficient for an inch of rain an hour, the amount of sewage due to water-supply and leakage may be neglected in calculations for size, since during such a storm it will rarely exceed one-fiftieth part of the whole quantity. It should not be forgotten, however, in deciding upon the shapes of the bottoms of sewers, since their efficiency depends as much upon an ability to remove promptly the minimum as the maximum quantity of sewage.

28. Having decided, from the above considerations, how great a discharge is to be provided for, the size of a sewer to accommodate it depends upon its inclination. The inclination, however, is approximately fixed by the contour of the land; because sewers must, as a rule, conform in slope to the surfaces of the streets they follow. Hence, with both the discharging capacity and inclination given, the third term, or size required, may readily be found by the principles of hydraulics. One unfamiliar with these principles should not be tempted to use any of the various "sewer formulæ" in which sizes of sewers are given in terms of acreage, rainfall, and inclination; since these vary greatly among themselves, not any can be universally correct, and some are very much the reverse. There are, however, certain standard tables which may be consulted. Perhaps the most convenient are those of Baldwin Latham, which at least err upon the side of safety.[1]

29. The parallelism of sewers to the general surface of the ground above them must be confined within certain limits. The inclination must be sufficient to give the sewage a cleansing velocity, even when the roadway is level or slopes in the opposite direction (as shown in Plate IV.); and it must not be so steep as to cause the sewage to flow in a rapid torrent, which, by sweeping along sand and stones on the invert of the sewer, would wear it away. The following is a rough rule for the minimum and maximum inclinations to be given to sewers of different sizes: —

SIZE.	Minimum.	Maximum.
4 inches	1 in 25	
6 to 8 "	1 in 50	
10 to 12 "	1 in 200	
2 feet	1 in 500	1 in 80
3 "	1 in 700	1 in 120
4 to 5 "	1 in 1,000	1 in 200
6 to 7 "	1 in 1,500	1 in 300

30. The inclinations given above might be modified in either direction by an engineer. Velocity of flow depends,

[1] Sanitary Engineering, by Baldwin Latham. Second edition. E. & F. N. Spon: London and New York.

really, not on the slope of the bottom of the sewer, but on that of the top surface of the sewage. For a short distance a sewer might be level, and yet have a good flow. It may sometimes be impossible to obtain a good fall, and become a question of having a flat sewer with sluggish flow or no sewer at all. It may then be wise to build one which will require constant flushing, or even to use a tide-gate, and to flush at each low tide. An excessive slope may be adopted with sufficient provisions for protecting the bottom of the sewer, or for retarding the velocity of the sewage. Such exceptional arrangements should be left to experts.

31. A defective combination of size and inclination such as is shown in Fig. 7 should be avoided. A sewer with steep pitch should not connect with one of equal size and

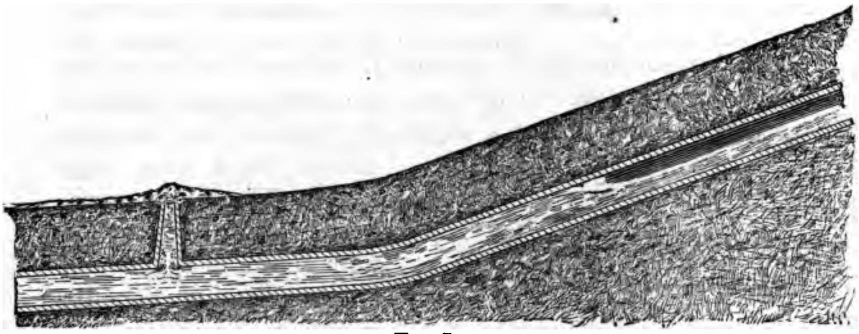


FIG. 7.

much less inclination. The steep sewer can carry much more sewage than the more level one, and in time of rain may bring to the latter more than it can receive. In such a case, both are filled to overflowing, and the sewage is forced by accumulation in the higher sewer through the man-holes, catch-basins, and house-drains connected with the lower one. The remedy consists in lessening the size of one sewer, or increasing that of the other.

32. Sewers should usually be built either circular or egg-shaped, as shown in Figs. 8 and 9. For equivalent cross-sectional areas, as regards quantity of material required, ease in building, and strength, the former is somewhat superior; the latter concentrates a slight flow better, and gives more convenient head-room for entering and cleaning. The circular shape is recommended for sewers of over five feet diameter,

for all sewers of steep slope, which clean themselves, and for sewers in shallow cuts where it is important to keep the top below the frost, or the flow-line as low as possible. The egg-

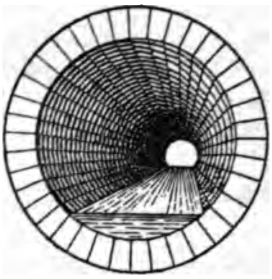


FIG. 8.

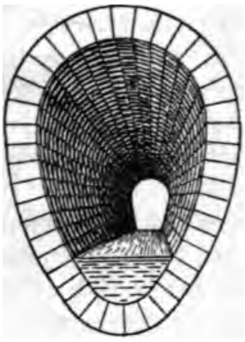


FIG. 9.

shape is recommended for sewers of less than five feet, on flat slopes or whenever the ordinary and storm sewage differ so greatly in amount that a slight dry-weather flow must be carried in a very large sewer. There are varieties of egg-shapes; but the form shown in Fig. 9 and in the diagram Fig. 10, giving its proportions in terms of the diameter of its invert arc, is the one generally referred to, and is that for which the tables of Latham and others have been calculated.

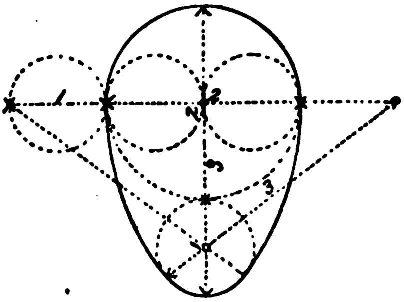


FIG. 10.

33. Flat-bottomed sewers are frequently built, and are always objectionable. The dry-weather flow, instead of being concentrated as in Figs. 8 and 9, spreads out into a thin sheet (Fig. 11) in which solid matters are apt to be stranded. So much more surface is washed by the sewage, that its velocity is much retarded. Rectangular wooden sewers, which abound in our cities and towns, can rarely be kept clean. Fig. 12 represents a very common form and its defects. To prevent the sewer from breaking, there is framework at intervals inside of it. This obstructs the water-way, lessens

velocity, and tends to cause deposits. If the posts are kept apart by sills on the bottom of the sewer, sludge accumulates

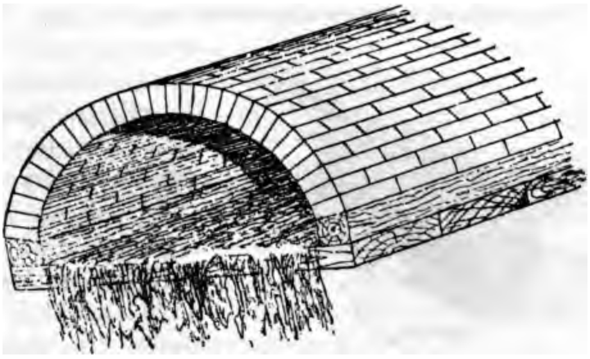


FIG. 11.

between them; and, if they are mortised into the floor-plank (as shown on the left of the figure), it lodges against their

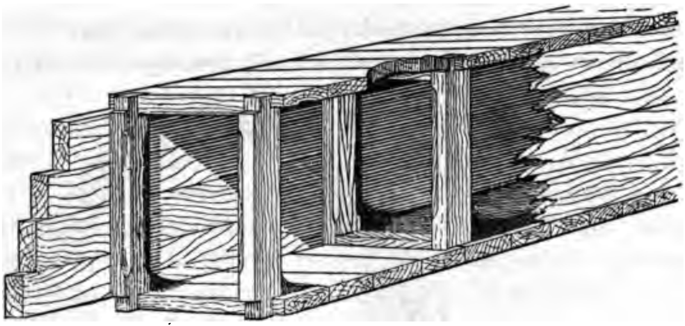


FIG. 12.

feet. A common way in which flat-bottomed sewers are broken is shown in Fig. 13.

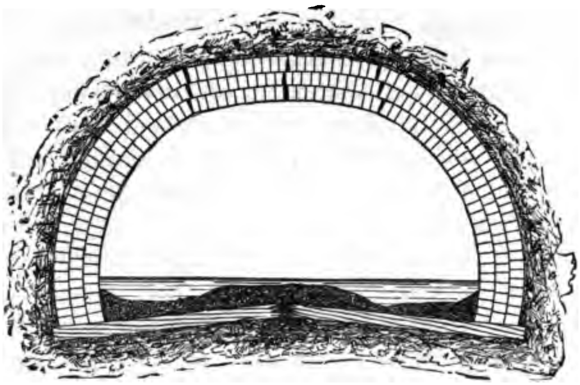


FIG. 13.

34. The best thing to do with sewers of such defective construction is to replace them with proper kinds; but when this for any reason is impossible they may, if large enough for workmen to enter, be somewhat improved by giving their bottoms a better shape. Fig. 14 illustrates one way of doing this by building an invert of vitrified-clay pipe, supported on a bed of concrete. To make the alteration, the flow of sewage need hardly be interfered with. From a temporary dam it can be carried in a sluice-box for a short distance, and allowed to flow into the new bottom as soon as laid.

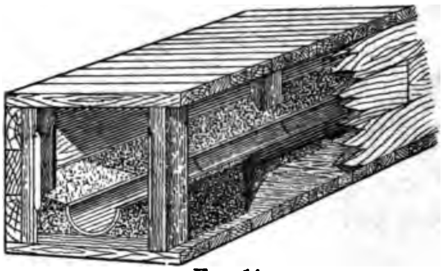


Fig. 14.

35. Although not desirable, yet there is no great evil in flattening somewhat the invert or arch of a sewer in order to carry it under some obstacle too low to permit the passage of the ordinary shape. Such a section as might be adopted is shown in Fig. 15.

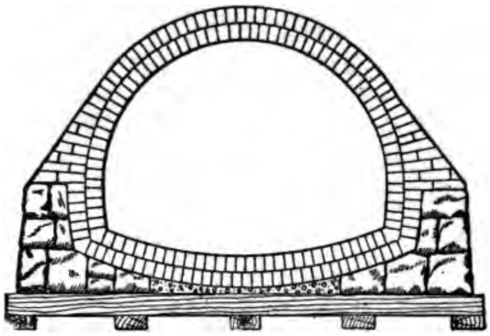


Fig. 15.

36. The best materials for building sewers over eighteen inches in diameter are bricks laid in hydraulic cement mortar. Sewers fifteen inches and under should be of vitrified-clay pipe. A sewer should very rarely be built of wood; for it is difficult to frame into the proper shapes, and to make connections with. It lasts indefinitely under water, but where it is alternately wet and dry it is sure to decay. Sewers are often built of stones; but these are too rough for such use, and, as tight joints cannot be made with them, a sewer so constructed is apt to pollute the neighboring soil.

37. Great care must be used in selecting bricks. They

should be of compact texture, burnt hard entirely through, uniform and regular in shape and size, and should give a clear ringing sound when struck with a hammer or trowel. Soft bricks will disintegrate in water, and even the quality called light-hards should be rejected. All brick for use in sewer-building should be inspected and culled over, improper ones being thrown out. A common laborer of undoubted honesty, and accustomed to handle bricks, can do this work well.

38. The cement used for making mortar should be of good quality; and the best way of insuring this is to buy from honorable dealers brands of established reputation. By also testing it occasional poor lots will be detected, but it is difficult to decide in this way between moderately good and very good cements. The results of even elaborate tests made by experts are often very fallacious. The old-fashioned "ball test" is sufficient. Mix a small ball of rather dry cement paste, let it stand in the air a few minutes till it begins to stiffen, then immerse in still water, not too cold, and if induration continues the quality is fair; if the ball disintegrates, the cement should be rejected. Not more than two parts of sand should be added to one part of American cement in making mortar, and only enough water to make a stiff paste. With good Portland cement, three and one-half parts sand may be used. In very wet or heavy ground, more of either kind of cement should be added. To resist abrasion, as in the invert of a very steep sewer, one part Portland cement and two parts sand is the very best mixture. Sand for mortar should be very clean and sharp.

39. Pipe-sewers should be of vitrified clay, salt glazed, true in shape, thoroughly burnt, too hard to cut with a knife, and without flaws. Cement pipes are often good, but it is hard to judge of their quality. For resisting acids and alkalies they have been proved inferior to clay.

40. The value of concrete, from its cheapness and adaptability to sewer-construction, is not sufficiently appreciated. It may be used with advantage for many purposes about a sewer, and should be prepared in the following way: At one end of a long mortar-box, mix dry one barrel of cement and two of sand, and then temper with water; at the other end spread evenly five barrels of clean screened gravel or broken

stone. Spread the mortar upon the stone, and turn the mass over with spades towards the now empty end of the box. Repeat the operation in the opposite direction. The mortar being thus thoroughly incorporated with the stone, the whole is ready for use. When put in place, it should be rammed till the water flushes to the surface.

41. The durability of sewers depends upon the excellence of the materials composing them, and true economy requires that these should be of the best: a dollar saved on a thousand bricks, or twenty cents on a cask of cement, may destroy the efficiency of the sewer. But, unfortunately, it is by buying cheap materials that many contractors expect to make their profit. It is well, therefore, that bricks, cement, and sewer-pipes should be furnished by the town authorities in charge of sewer-work. To avoid a wasteful use of such materials, the contractor should be required to purchase them from the town at fixed prices, specified in his contract, to be deducted from moneys due him under it; and, that there may be no claims on account of real or fancied delay in delivering materials, he should receive them at some town-yard or other specified place of deposit.

42. Sewers may be built either by a municipality itself by days' labor under its own superintendents, or by contract. Each way has its merits and its evils. If good superintendents can be found, and they are untrammelled in the selection of their subordinates, the work will be more easily kept under control, the method of construction can be varied as occasion demands, the surroundings of the work can be kept neater, less annoyance caused to neighboring residents, and usually a better class of work can be obtained than by contract; but it is hard to find good superintendents, and still harder to leave them untrammelled. City work, at least, is often regarded as a reward for political services, or a charitable asylum for the destitute and infirm; and it is common experience that laborers do not work as hard for a city as for an individual. Moreover, a full set of machinery and tools must be purchased, and afterwards disposed of at great loss; so that, as a rule, work done in this way is apt to be expensive.

43. Building by contract, on the other hand, saves a great deal of trouble. Contractors have the necessary plant, and are accustomed to the handling of men and machinery.

Through competition favorable prices are obtained, — sometimes lower than the cost of the work, — and the contractor takes all risks. But, a contractor's only object being to make money, he has a constant temptation to slight his work; and its character can rarely be changed, after it is begun, without incurring exorbitant claims for extras. A good general rule is, that, when the character of the work required is so well known beforehand that full and explicit specifications for it can be drawn, contract-work is the most economical. When this is not possible, and the work can be divorced from politics, labor by the day is more satisfactory.

44. The contract should be prepared by an engineer: he alone is capable of writing its specifications. There are many clauses and modes of expression whose force and intent have been the subject of judicial decision, so that they cannot safely be altered. In awarding a contract, it is best to accept no contractor, however low his prices, who cannot furnish testimonials to his energy, ability, financial standing, and general reputation for fair dealing. After accepting a contractor, he should be assumed to be honest till proved otherwise. Contractors are a valuable class to the community, and often esteem highly their good reputation, which is their capital. Fair treatment appeals to their honor, and manifestations of a desire to help them when possible will act as incentives to faithful services.

45. All contract work should, however, be constantly watched. An honest contractor will not object to this, and a dishonest one will need it. An inspector who cannot be bribed should be at all times on the ground. The qualities required in a good inspector are rare. He should be a thorough mechanic, a mason if possible, with good judgment and an even temper. He should see that the work is done in conformity with the specifications, keep notes of the character of soil, methods of construction, position of house-drain connections, and a force account, from which the cost to the contractor can be estimated.

46. Experience has taught all that it is necessary to know about the requisite thickness of the walls of sewers. Under ordinary conditions, those up to two and one-half feet in diameter can be built of one ring of brickwork four inches thick; thence to six feet inclusive, two rings or eight inches

will be sufficient; and up to ten feet, three rings or twelve inches. A coat of plastering between the rings and over the arch will tend to prevent leakage.

47. The character of the ground in which sewers are to be built determines their sectional shape and method of construction. An unyielding foundation is essential. Where the ground is so hard that it can be trimmed to the proper shape for receiving the invert, the latter may be laid directly on it as in Sect. D, Plate IV. p. 283. Where the earth is of a looser nature, and tends to fall down, a "cradle" support, consisting of two layers of inch boards on plank ribs, should be used (Sect. E). In bad ground a timber platform with side-walls will be necessary (Sect. C). Where there is mud or other compressible material under the sewer, it should either be taken out, and concrete substituted (Sect. B), or, if too deep to make this economical, the sewer should be supported on piles (Sect. A). The usual defects produced by a yielding foundation are depicted in Fig. 16.

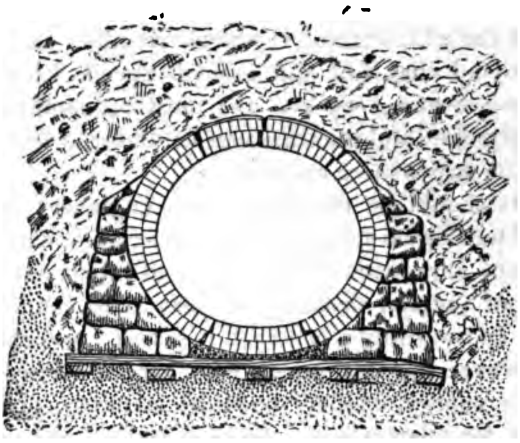


FIG. 16.

48. A sewer is apt to be broken, as shown in Fig. 17, at a point where it passes from a rigid foundation of piling or thick concrete, to a slightly compressible one of earth or sand. This may be avoided by tapering off the concrete as shown in the profile Plate IV. at B, or by extending longitudinal stringers under the sewer to some distance beyond the rigid foundation.

49. Too much stress cannot be laid on the importance of ramming back solidly the refilled earth about the arch. The tendency of an arch is to spread at its springing-line, and its stability depends upon the side pressure being sufficient to counteract this tendency. If the back-filling be thrown

loosely into the trench, or even if it be rammed into place but in too thick layers, it will be somewhat compressible, and as the trench is filled up, and the arch receives its load, the

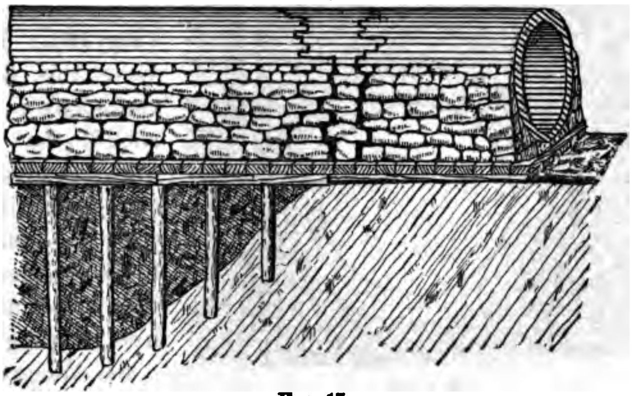


FIG. 17.

latter will spread more or less at its sides, and sink at its crown, so that a condition will ensue similar to that exhibited in Fig. 18. Probably one-half of the sewers that fail do so because the back-filling about the haunches is insufficiently rammed.

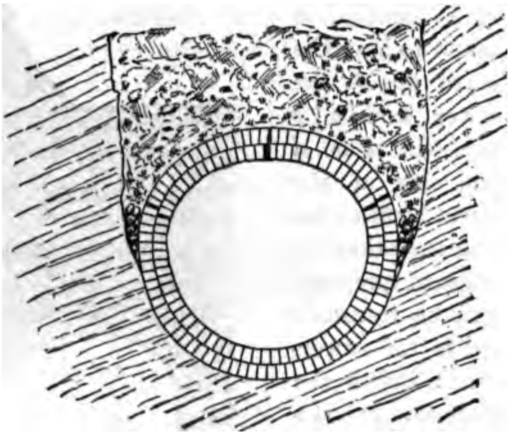


FIG. 18.

50. The occurrence of cavities, arising from the withdrawal of the sheet-planks, is another frequent cause of the spreading of sewers. If the trench be partially back-filled before the planks are pulled up, the space occupied by the plank is left as a deep narrow hole. Stones or lumps of earth will fall into this hole, and, lodging when part way down, will form obstructions to filling the space below. Occasionally

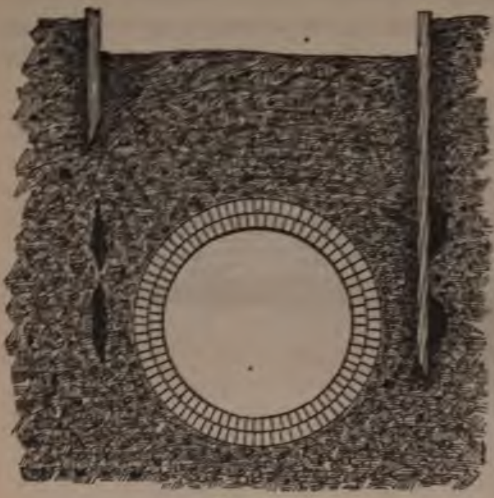


Fig. 19.

the running of sand through joints between the planks leaves cavities behind them (Fig. 19). To obviate this danger the sheet-plank should be withdrawn gradually as the back-filling is put in, and the holes tamped solidly with a narrow iron tamping-bar.

51. When a sewer is built, not in a street, but on a line which may in future be used for that purpose, and will then require to be filled and graded, great care should be taken to have the earth about the sewer solidly packed. For, if one side of the street be filled before the other, an unequal pressure will be transmitted to the sewer-arch; and, if the material at its sides be compressible, distortion will ensue, as shown in Fig. 20. When such an event is feared,

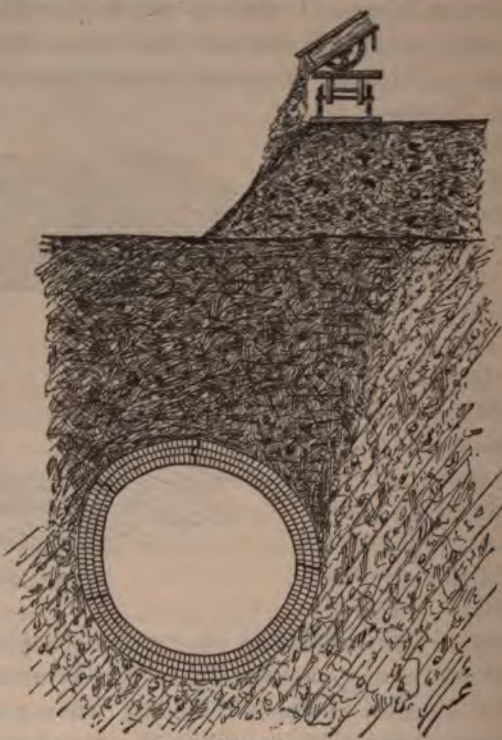


Fig. 20.

and the nature of the ground is spongy, it will be best to leave in the sheet-plank, and to fill around the sewer up to its crown with concrete.

52. When pipe-sewers fail, it is usually owing to improper methods of laying them. They are sometimes laid upon the bottom of the trench, or upon a board resting upon the flanges or collars, instead of upon the body of the pipe with depressions dug out for the flanges. In the former case each

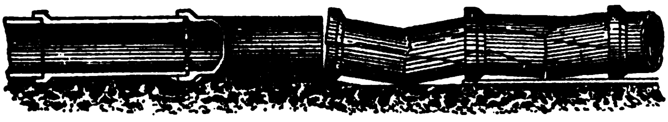


Fig. 21.

section of pipe acts as a beam resting on supports two or three feet apart, and is apt to be broken by the weight of the back-filling above it (Fig. 21). The mortar uniting adjoining sections of pipe sometimes projects into the interior, as indicated at one joint of the same figure; and, unless

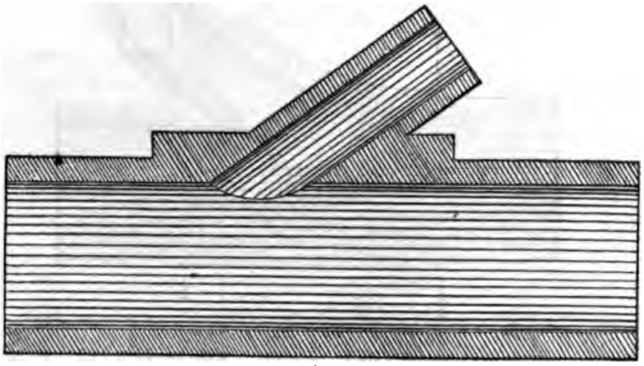


Fig. 22.

removed with a swab or scraper, forms an obstruction behind which sludge accumulates.

53. The junction of one sewer with another should never be built at an angle of more than 35° (Fig. 22), and the best way to bring them together is by curves tangent to each other. By the latter method the currents in both sewers unite with least disturbance and with least retarding of their velocities. The construction of a tangent connection for brick sewers,

sometimes called a bell-mouth, is shown in Figs. 23, 24, 25,

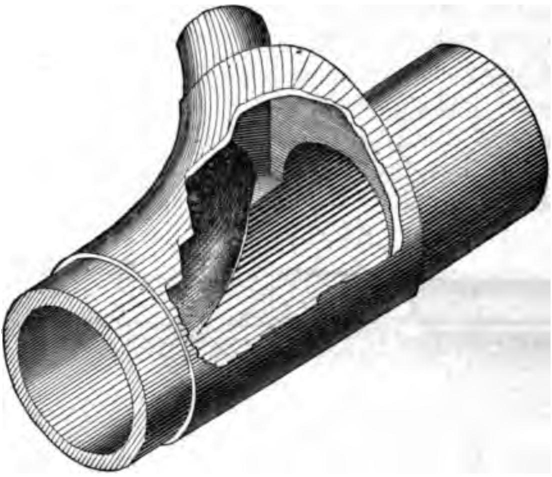


Fig. 23.

and 26. It is not difficult to build, and is frequently used

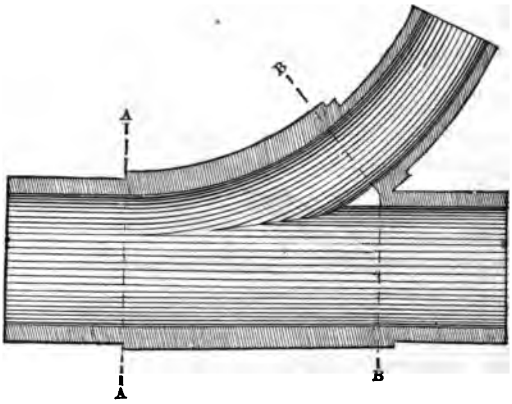


Fig. 24.

abroad, but not as often in this country as its merits deserve.

54. Inlets for house-drains to connect with should be built into a sewer during its construction. It mars a sewer greatly to be frequently broken into for the purpose of connecting drains. Pieces of sewer-pipe called slants are made

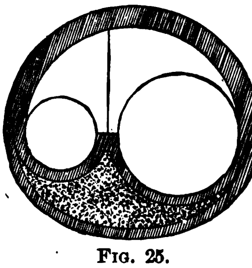


Fig. 25.
SECTION AT BB.

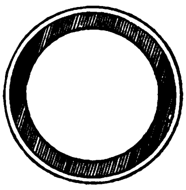


Fig. 26.
SECTION AT AA.

specially for drain connections. As many of them should be put in as can possibly be needed, as it is far better to have too many of them than too few. They should be not more than twenty-five feet apart on each side of the sewer, if there is a chance that the land bordering on the street may eventually be cut up into lots of that front width. Six-inch connections are large enough, and they should enter the

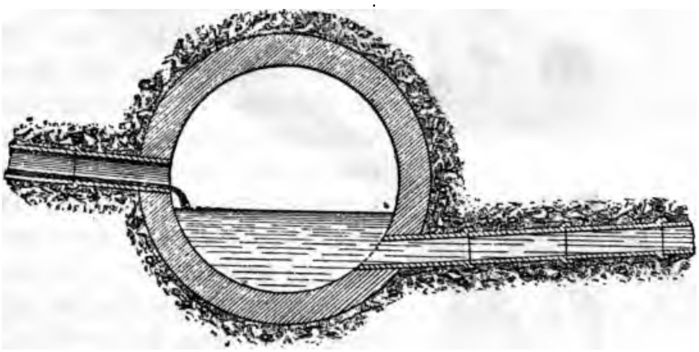


FIG. 27.

sewer not much below its springing-line. Theory would require that the tops of connecting sewers should be at the same level, so that when running full neither should cause back-water in the other; but sewers rarely run full, and in practice it is found sufficient to have their ordinary flow-lines equally elevated. Fig. 27 shows a house-drain filled with back-water from the sewer, on account of its connection being too low, and another entering at a proper height.

55. Provision must be made for entering sewers to clean them, where cleaning is necessary, and also for ventilation. Both of these ends are accomplished by building a sufficient number of man-holes with perforated covers. On small sewers a man-hole should be built at every change of direction or inclination; or, what amounts to the same thing, such changes should begin at man-holes. On sewers less than two feet in diameter, man-holes should be not more than a hundred and twenty-five feet apart, to afford frequent facilities for inspection, and detection and removal of deposits; on no sewer should they be more than three hundred feet apart, on account of ventilation. In a well-designed system, nearly all putrescible matters will be removed before they begin to decompose; but slight deposits, yielding a little sewer-gas,

may occur, and, if the latter is sufficiently diluted with fresh air, it will be innocuous and inoffensive. Forms of man-holes are shown in Figs. 28, 29, and 30. On large sewers, for the sake of economy, for alternate man-holes may be substituted ventilators of sewer-pipe, or, better, cast-iron water-pipe, similar to that shown in Fig. 31. The catch-pits, shown in the figures at the tops of man-holes and ventilators, are to prevent dirt, stones, and street-detritus from dropping into the sewers. The sump-holes often built below man-holes (Fig. 32) answer no good purpose, and violate the first principle of sewerage by arresting in its course what ought to be promptly removed.

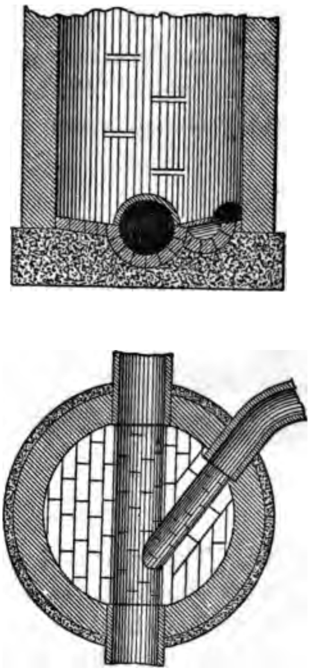


FIG. 28.

56. Street catch-basins must also be built to intercept the gravel and detritus which would otherwise be swept into the sewers with the rain-water during a storm. They should not be more than three hundred feet apart, and on both sides of the street. Three such structures are shown on Plate III. Fig. 2 is a kind often used, and its trap is made by a cast-iron hood (Fig. 5) hinged over the outlet-pipe, and made fast to the brick-work by a plastering of cement at its edges. Its merit consists in the fact that the hood can be easily removed, and a rod

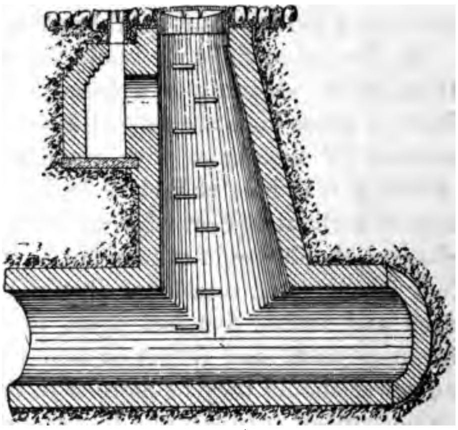
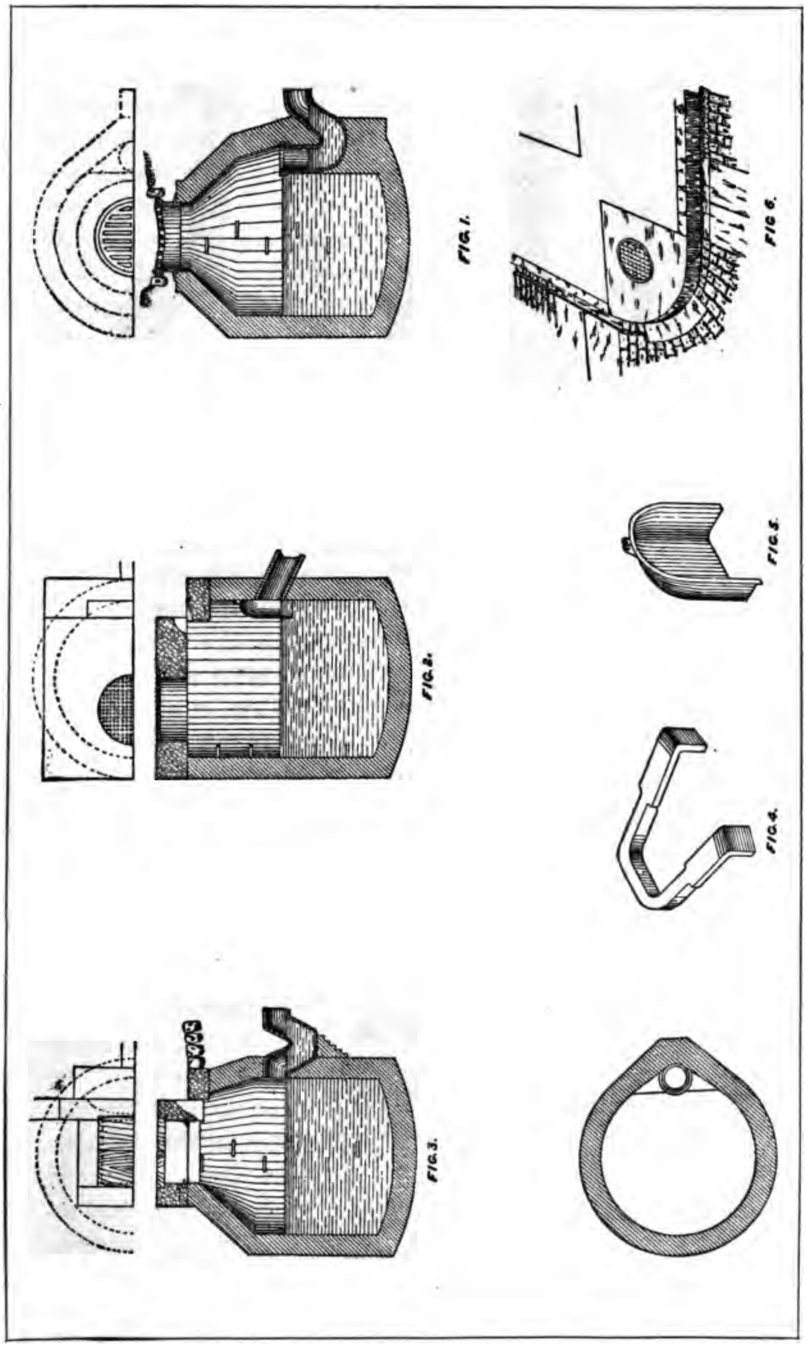


FIG. 29.

PLATE III.



or light pushed down the straight pipe to locate the position

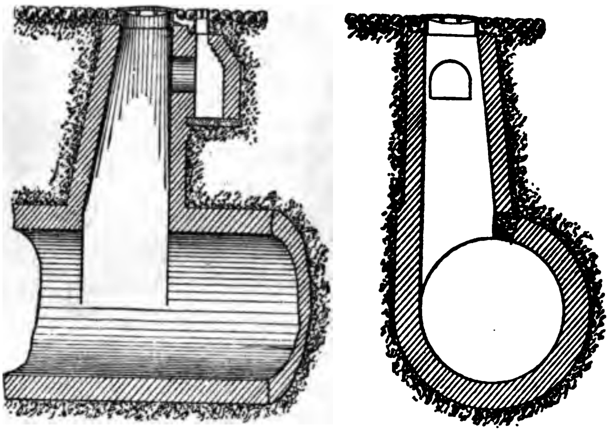


Fig. 30.

of any break or stoppage. This trap is unsealed, however, while it is being cleaned; and at that time any surplus water must be poured on the street, or the hood taken off and again replaced. The other forms of trap, shown in Figs. 1 and 3, made of shapes of pipe always in the market, retain their s e a l s, while the basin is being cleaned, can be bailed into, and, being less exposed to the circulation of air, the water in them evaporates slowly. In time of drought, a bucketful of water is all that is required to renew their seals, instead of barrelfuls as in Fig. 2. The pipe from the former ones can-

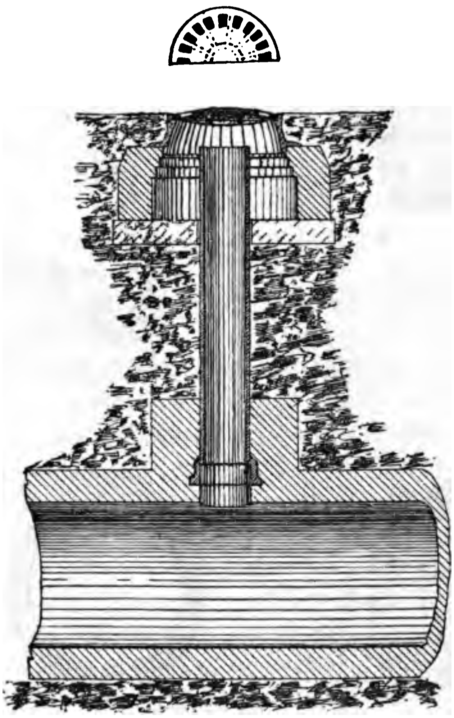


Fig. 31.

not be as readily examined as the straight one, but on account of their other merits these traps are recommended. Several ways of arranging the covers and inlets to the basins are given. Fig. 6 shows one at a street-corner. Fig. 4 is a simple and strong ladder-iron to be built into the brickwork while the basin is being constructed.

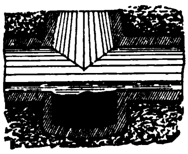


FIG. 32.

57. The more skilfully a sewerage-system is designed and built, the less care need be taken of it afterwards. But, if any deposit should occur in the sewers, it must be promptly removed. The easiest and cheapest way of doing this is by flushing the sewers with clean water or with the sewage itself. Where it is possible to occasionally turn a stream of water from a brook or reservoir into the upper part of a system, this will be found the simplest way of washing out deposits. Another way is to provide at intervals in the sewers arrangements by which the sewage itself may be dammed back until a large quantity collects, when, the temporary dam being removed, the water rushes down with great velocity, sweeping any accumulations of sludge along with it. The best point to apply the water is at the upper end or ends of the sewer-systems. The flush then acts for their entire lengths, and with most intensity upon the higher and smaller portions, which receive least sewage, and most need cleaning. For this reason all sewers, large or small, should start from man-holes, arranged for storing a quantity of water. An example of such a man-hole is given in Fig. 33. This is for a pipe sewer; and the portion entering the man-hole is of iron, bearing a hinged cover, which can be raised by a chain after the man-hole has been partially filled with water, drawn from a hydrant or brought in carts. Flushing gates for larger sewers should

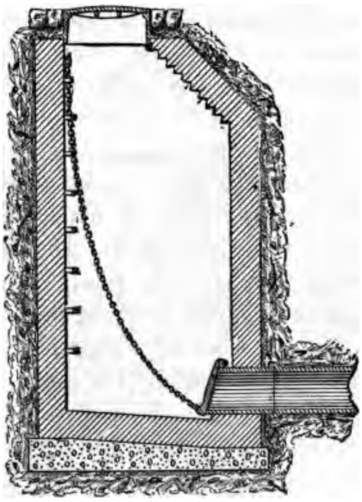


FIG. 33.

be designed by an engineer. Such solid deposits as cannot be stirred up and moved in this way must be taken out by hand through the man-holes.

Accumulations in the street catch-basins must also be removed by hand, at a cost of two or three dollars for each cleaning. Those at the foot of steep slopes, on unpaved streets, may require to be attended to after every heavy rain, and should be larger than the others.

58. It is absolutely essential, in building a sewerage-system, to file for future reference a plan showing every portion of each sewer and its appurtenances. Such "record plan" should be on a scale of not less than one hundred feet to an inch, with details on a larger scale. It should show the exact location of the sewer with reference to street-lines, and the positions of man-holes and catch-basins. All house-drain connections, with their sizes, should be shown, noting their precise distance from fixed points, as the lines of street-intersections; so that, when a house-drain is to be built, the place to dig for its point of connection can be determined by measurements above ground. A profile should show the elevations of street and sewer, and the inclination of the latter, together with the character of the soil. The size and any different methods of construction of the sewer should be shown on a large scale, and any other items of interest recorded. A sample plan, rather more elaborately finished than is essential, is given in Plate IV.

59. The cost of a sewer depends upon the prices of the materials of which it is built, the rate of wages paid laborers and masons, the nature of the ground to be excavated, whether clay, gravel, quicksand, or rock, the quantity of water met with, and the mode of construction required. It is obvious that no scale of prices can be made, based simply upon internal diameter and depth of cut. It may, however, at times be convenient to have even a guess at the cost, or comparative cost, of sewers under ordinary conditions. The prices on the diagram, Fig. 34, have been calculated on an assumption of a moderately favorable character of material to be excavated, and a rate of wages for common labor of $1.25 a day, with other prices in proportion. Even under these conditions it gives but a rough approximation to the truth, and should be used with caution.

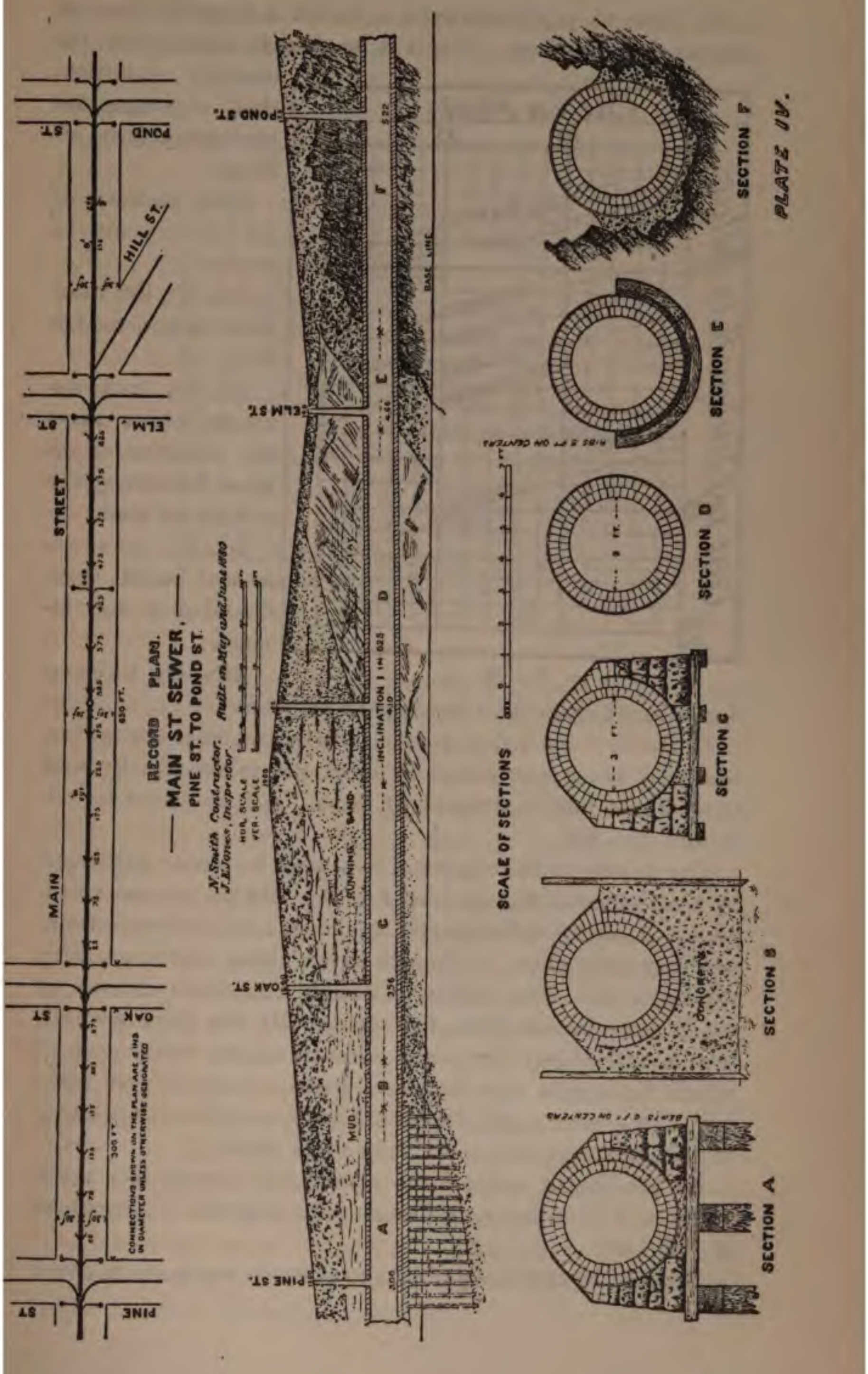

RECORD PLAN.
— MAIN ST SEWER, —
PINE ST. TO POND ST.
N. Smith Contractor.
J. E. Jones, Inspector.
MAIN STREET
PINE ST.
OAK ST.
ELM ST.
POND ST.
HILL ST.
MUD.
RUNNING SAND.
INCLINATION 1 IN 625
BASE LINE
SCALE OF SECTIONS
SECTION A
SECTION B
SECTION C
SECTION D
SECTION E
SECTION F
CONCRETE

PLATE IV.

60. How to pay for sewers, is rather a financial than an engineering problem. Yet it is so closely allied with the sanitary question, that a suggestion may properly be offered.

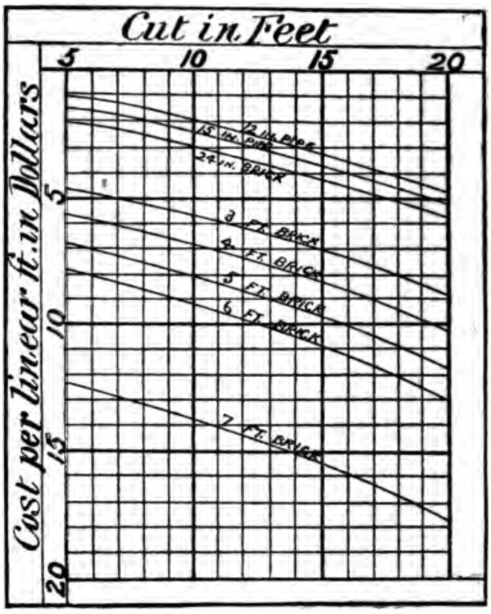


FIG. 34.

Four methods of payment are in use: —

1st, By the town from its general tax levy.

2d, By assessments based upon the valuation of estates bordering the streets sewered.

3d, By assessments based upon the area of said estates.

4th, By assessments based upon their frontage in linear feet.

By the first method, persons living remote from the sewers, who may never be reached by them, are taxed equally with those whose land is drained by them. All are taxed for the benefit of a few.

The defects in the other methods may be better explained by a reference to the sketch, Fig. 35. By the second method, lot A, being valuable, though with a single house-drain, may pay more than lot B, with seven cheap tenements, fifty residents, and four drains, although the latter derives so much more benefit from the sewer. By the third method, lots A and D pay the same amount as the tannery at C, which discharges one hundred times as much, and more offensive sewage; and the vacant lot F, to which the sewer is of no advantage, pays more than all of them.

By the fourth method the corner and vacant lots again suffer, and D with a single house pays four times as much as E with two.

It would be obviously unjust to assess sewer-taxes to cover

the cost of the actual sewer on which the estates front, since sewers vary greatly in cost but not at all in their use to the abutters. A main sewer may cost twenty dollars a foot, and take the flow from a whole city, but it serves the land fronting it no better than a twelve-inch pipe would do.

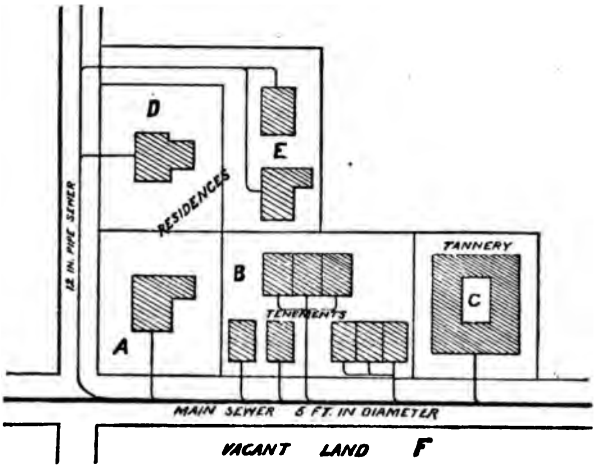


FIG. 35.

By the above plans, moreover, the whole assessment must be paid at oncĕ, often entailing a serious hardship, especially upon the owners of unimproved lands.

There seems to be no valid reason why people should not pay for sewerage accommodations, as they do for most other things, in proportion to value received, or why they might not do so by partial yearly payments.

By this method sewers would be built by a sewerage-loan, to be repaid by sewer-taxes, assessed for a term of years, on those who use the sewers, in proportion to that use; that is, to the quantity of sewage contributed.

This method would be equitable: there seems to be no reason why it should not be practicable. Sewage is substantially the contaminated water-supply, and its amount for any dwelling could be approximately estimated.

Such a system was once contemplated by one of the towns of this State, and an act to authorize it was drawn by a very able lawyer. Although the town in question took no further action in the matter, the act contemplating this plan is thought of sufficient value to reprint for the consideration of other towns in the Commonwealth.

BILL.

Be it enacted, &c.

SECTION 1. That the Town of Medford may, at a meeting to be called for that purpose, choose by ballot four competent and discreet men, being inhabitants of said Town, who, together with a member of the Board of Selectmen of said Town, to be annually appointed by them from among their number, shall constitute a Board of Public Works for that Town. Two of the persons thus chosen by ballot shall be elected to hold their office for the term of one, and two for the term of two years, from the date of their election, if such election be at an annual meeting of the Town, — otherwise, for one and two years, respectively, from the next preceding annual town meeting, — and they shall hold said offices until their successors are elected and qualified. At every annual meeting subsequent to said first election, the voters of said Town shall choose by ballot two persons qualified as aforesaid to be members of said Board, to serve for the term of two years, and until their successors are elected and qualified.

SECT. 2. Said Board shall have and perform, exclusively, all the powers and duties concerning laying out, altering, making, repairing, or discontinuing streets, ways, and sidewalks in said Town, which now are, or may hereafter be, vested by law in selectmen and surveyors of highways, and also all the powers and duties which now are, or may hereafter by law be, vested in the Water Commissioners for said Town; and said Board of Public Works are further empowered, when thereto duly authorized by a majority of the voters present and voting thereon at any legal meeting of said Town, to lay out, make, and maintain in said Town all such main drains, or common sewers, as they shall adjudge to be necessary for the public convenience, or the public health, through the lands of any persons or corporations, or through the streets, highways, or townways therein, and to cause the same to be discharged into the tide-waters of Mystic River; and whensoever any land or real estate shall be taken by virtue of this Act, or when any person or corporation shall suffer damage to their property by reason of the laying, making, or maintaining any such drain, the proceedings for taking said land, and the rights and remedies for the ascertaining and recovery of such damages, shall be had in conformity to the second and third sections, respectively, of the hundred and eleventh chapter of the Acts for the year 1869.

SECT. 3. To provide for the payment of the expense of laying, making, and maintaining such drains, the said Town may issue, from time to time, notes, scrip, or obligations of said Town, to be denominated on the face thereof, "Medford Sewerage Loan," to an amount not exceeding, in the whole, thousand dollars, and bearing interest not exceeding per centum per annum; said interest to be paid semi-annually, and the principal to be payable at periods not more than years from the date of such notes, scrip, or obligations respectively. All such notes, scrip, or obligations shall be signed by the treasurer of said Town, and countersigned by the chairman of the board

of selectmen, and a record of all such notes, scrip, or obligations shall be made and kept by said treasurer; and said Town, by its selectmen, may sell the same or any part thereof, or pledge the same for money borrowed for the purposes aforesaid, at such rates and upon such terms as they may deem proper. And the said Town may assess and collect, from time to time, such amounts as it may deem needful towards a sinking fund, to be created in the manner hereinafter provided for the payment of the principal of the money so borrowed, and also to pay the interest thereon, and to keep said drains in operation and repair as herein provided, in the same manner as money is assessed for other town purposes.

SECT. 4. The said Board of Public Works shall, in each year, on or before the day of cause to be made a statement or estimate of interest, payable during said year, upon the notes, scrip, or obligations aforesaid, of the probable cost of maintaining such sewers, and of such further sum as will, in their judgment, be necessary towards the creation of a sinking fund sufficient, with the accumulated interest thereon, to pay said notes, scrip, and obligations at their maturities; and, of the sum thus ascertained or estimated, they shall assess such part, not exceeding two-thirds, as they may deem equitable, upon and among all such persons as shall enter their particular drains into such main drains or common sewers, or who, by more remote means, receive benefit thereby, from draining his or their cellar or land. Such assessments shall be made and distributed to and among said parties, in proportion to the comparative amount of sewage discharged into said main drains or common sewers, from the premises of said parties respectively, — the same to be estimated or measured by said Board of Public Works, or under their direction, in such manner as they may deem most practicable; such assessment to be made, determined, and certified by said Board of Public Works, and notice thereof to be given to the party to be charged, or his tenant or lessee.

SECT. 5. Assessments thus made shall constitute a lien on the estate thus assessed, to be enforced by said Town within the period and in the manner set forth in the fifth section of chapter forty-eight of the General Statutes; and any person aggrieved by such assessment may apply for a jury within the time and in the manner provided in the sixth section of the same chapter of the General Statutes, and upon such application the proceedings shall be had in all respects in conformity with said section.

SECT. 6. The treasurer of said Town, in each year, shall be the commissioner of said sinking fund, shall give bond with sureties for the faithful performance of his duty, and receive such compensation as shall be fixed by a vote of the Town. There shall be assessed by the Town in each year, in manner aforesaid, such sum towards the creation of said sinking fund, as shall, together with the proceeds of the assessment made as aforesaid for that purpose on parties who shall use said sewer in manner as aforesaid, be deemed by the Town sufficient to form a fund, which, with its accumulations, will pay said notes, scrip, and obligations at their maturities. Separate accounts of the sums received from said tax, and from said assessments for the use of said drains, shall be kept

by said treasurer; and the same and the accumulations thereof shall be invested by him, under the direction of the selectmen, either in the notes, scrip, or obligations authorized by this act, at not exceeding their par value, or in such loans or such securities as by law the funds of savings banks may be invested in; except that no portion thereof shall be loaned to the Town, or on personal security.

SECT. 7. The selectmen shall, as often as once in each year, examine the accounts and securities of said sinking fund; and a report of the condition and amount of said fund shall be made by the treasurer to the Town each year, at its annual meeting, as well as a report by the selectmen of their examination thereof.

HEALTH OF TOWNS.

TYPHOID-FEVER IN FIVE TOWNS OF MIDDLESEX COUNTY.

BY

DR. S. W. ABBOTT OF WAKEFIELD.

TYPHOID-FEVER IN BROOKLINE.

BY

DRS. R. AMORY AND G. K. SABINE.

TYPHOID-FEVER, DIPHTHERIA, SCARLET-FEVER.

TYPHOID-FEVER

IN READING, WINCHESTER, WAKEFIELD, WILMINGTON, AND LYNNFIELD.

REPORTED BY DR. S. W. ABBOTT OF WAKEFIELD.

THE following summary of certain cases of typhoid-fever is compiled from a report made to the Middlesex East District Medical Society a few months since, and by its permission is offered to the State Board of Health as a contribution to the study of the causes of typhoid-fever, regarded from a sanitary point of view. These cases were reported in reply to a circular, issued under the direction of a committee on systematic observation, this circular being the result of a discussion, having reference to certain outbreaks of typhoid-fever clearly traceable to local causes. The blank form which was issued also served the additional purpose of inculcating vigilance on the part of observers, its possession naturally leading each physician to habits of greater carefulness in observation.

In the words of the report alluded to, " Setting aside hypotheses in regard to the cause of disease, the object of the Committee has been, to collect facts from the observation of physicians in this district, and arrange them in a systematic shape for presentation."

Replies were received from four physicians only, embracing cases in the towns of Winchester, Reading, Wakefield, Wilmington, and Lynnfield; all these towns being in Middlesex, except Lynnfield, which is in Essex County.

One point appears especially prominent in this report, — the dangerous proximity of the *well*, the *privy*, and the *cesspool*. These three things are intimately associated with household life in the country-towns of New England; and although we might wish them all abolished, especially when all existing together as sometimes found in a loose soil, within a circle of five metres or less in diameter, still the factors of this dangerous triangle do constantly appear, and are continually multiplying, wherever new houses are in process of erection, in country villages, in farming communities, and in the smaller cities without a fresh-water supply.

So constantly does the proximity of these factors of disease appear in connection with the occurrence of typhoid-fever, that we may almost apply to them the precision of a mathematical formula. Let a represent the well; b, the privy-vault; c, the cesspool.

From these three we may with considerable assurance construct a formula in which, with occasional help from the house-cellar, the stable, the leakage of sewer-gas, and some other factor at present unknown, the probability of the appearance of typhoid-fever at some future day shall be represented by the relative looseness of soil, and the distance of *a* from *b* and *c*.

Such a formula is reasonably limited by certain conditions; for example, the direction of underground water-flow between *a* and *b* or *c*, the direction of surface slopes between the same, the mode of construction of *b* and *c*. In country towns these are commonly of loose stones, boards, plank, brick, either with or without cement, or, as in the majority of instances, a simple excavation in the soil. Even in the case of cemented vaults it is probable that leakage into the surrounding soil occurs in a few years on exposure to the frost.

The reporters of the following cases, four in number, constitute but a small portion of the physicians living in the limits of the district referred to, all of whom doubtless might contribute a similar experience; and a report from the whole State would annually show an appalling harvest of preventable disease and death.

This subject has been thoroughly illustrated in past reports of the State Board of Health; but the constant recurrence of neglect of sanitary precautions only proves the need of greater vigilance on the part of local boards of health and of physicians in general practice. The former are too often ignored or considered as sinecures in country districts; but the very fact of the greater frequency of typhoid-fever in those districts than in the cities, on account of the absence of a general water-supply and of adequate sewerage, proves the necessity of the existence of such boards, and of their constant supervision of the location of wells and the proper construction and location of sewers and vaults.

In the remoter and more sparsely settled farming districts, where every house has abundance of room amid broad fields on either side, neglect of sanitary precautions is without excuse. But in the crowded condition of some country villages, and the consequent diminutive size of house-lots, often with neighbors on either side and also in the rear, with scarcely standing-room for the house itself, it becomes a difficult sanitary problem *where the well shall be dug*. A wiser course might be to forbid its construction altogether, especially when stables, vaults, drains both old and new, and heaps of rubbish, surround the house-lot on every side except the street boundary.

It is also clearly the duty of every physician in general practice, on the occurrence of a case of typhoid-fever, not to rest

satisfied with the diagnosis and treatment of his patient, but to make careful inquiry as to the sanitary condition of the premises, with a view to the prevention of further infection.

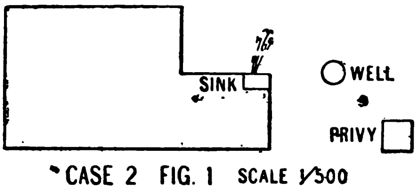
TYPHOID-FEVER. — *Inquiries of the Middlesex East Medical Society, Reported by Drs.* F. WINSOR of Winchester, F. F. BROWN of Reading, J. P. ELLIOTT of Wilmington, and S. W. ABBOTT of Wakefield.

1.	2.	3.	4.	5.	6.	7.	8.	9. — REMARKS ON SURR'DING INFLUENCES.
Cases.	Age.	Sex.	Month when taken sick.	Number of days ill.	Recovered.	Died.	Residence.	CONDITION OF PATIENT'S RESIDENCE. Were there other cases in the same house, or in the neighborhood. If patient was taken ill elsewhere, what was the condition of house where he was taken ill. *a. Well.* — Condition and quality of *water.* Result of analysis, if any was made. Is *aqueduct water* used. If so, state its source. *b Privy.* — What kind of *vault*, if any. *c. House Sewage.* — How disposed of. What kind of *cesspool*, if any. *d. House Cellar.* — Damp or dry. How ventilated. *e. Stable and its Cellar.* — Disposition of *manure.* *f.* Nature of *soil* around *a, b, c, d,* and *e.* Direction of slopes and water-courses.
			1873.					
1	23	F.	Aug.	25	–	Yes.	Reading . .	
2	9	M.	Oct.	15	Yes.	–	" . .	
			1875.					
3	21	M.	July.	20	–	Yes.	" . .	
4	10	M.	Sept.		Yes.	–	" . .	
5		M.	Oct.	2	"	–	" . .	
6	to	M.	Nov.	to	"	–	" . .	
			1874.	4				
7	28	F.	–	wks.	"	–	" . .	
8		F.	–		"	–	" . .	
			1876.					
9	50	F.	July.	50	"	–	" . .	
10	21	F.	Sept.	35	"	–	" . .	
11	30	F.	"	21	–	Yes.	" . .	
12	28	F.	"	28	Yes.	–	" . .	
13	25	M.	"	28	"	–	" . .	
14	28	M.	Oct.	14	"	–	" . .	
			1877.					
15	17	F.	Aug.	21	"	–	" . .	
16	17	M.	Sept.	28	"	–	" . .	
17	11	M	"	21	"	–	" . .	
18	37	F.	"	14	"	–	" . .	
19	12	F.	"	14	"	–	" . .	
20	17	F.	March.	13	–	Yes.	Winchester .	
21	20	F.	"	7	–	"	" .	
			1873.					
22	20	M.	Dec.	–	Yes.	–	" .	
			1874.					
23	62	F.	Jan.	–	"	–	" .	
			1877.					
24	14	F.	Nov.	20	–	Yes.	" .	
25	–	M.	Sept.	17	Yes.	–	Wilmington .	
			1872.					
26	4	F.	April.	50	"	–	Wakefield .	
27	5	F.	"	15	"	–	" .	
28	7	M.	"	30	"	–	" .	
29	12	F.	"	25	"	–	" .	
30	15	M.	May.	25	"	–	" .	
31	17	F.	"	30	"	–	" .	
32	25	M.	"	55	"	–	" .	
33	31	M.	"	30	"	–	" .	
34	13	M.	June.	50	–	Yes.	" .	
35	6	F.	"	30	Yes.	–	" .	
36	9	F.	"	25	"	–	" .	
37	11	M.	"	25	"	–	" .	
			1877.					
38	65	F.	Sept.	35	"	–	Lynnfield .	
39	35	M.	Oct.	50	"	–	" . .	
40	31	F.	"	60	"	–	" . .	
41	45	M.	"	50	"	–	" . .	
42	14	M.	"	25	"	–	" . .	
43	5	M.	Sept.	30	"	–	" . .	
44	8	M.	"	32	"	–	" . .	
			1879.					
45	36	F.	Nov.	33	"	–	" . .	
			1876.					
46	8	F.	Oct.	20	"	–	Wakefield .	
47	10	M.	Nov.	20	"	–	" . .	
48	30	F.	"	15	"	–	" . .	

The following summary comprises the cases already mentioned: —

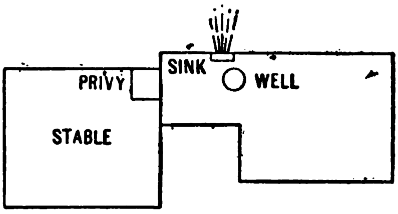
CASE 1. — Bad taste in well-water. Well not more than five and a half metres from privy. Vault of wood, old, and probably not tight. House-sewage intended to run into barn-cellar at a distance, but really saturates the ground, usually from clogging the pipe. Cellar damp. Ground level. This patient had mild typhoid-fever in 1870 in another house, the condition of which was not inquired into.

CASE 2. — Well and privy within four metres of each other; have been used for many years. Vault of loose stones. Sink-water flows out over the surface of the ground near the well. Soil gravelly. Surface slopes off a little in direction of privy. In 1869 the nearest neighbor who used this well had severe typhoid-fever. Water had a bad taste and odor.

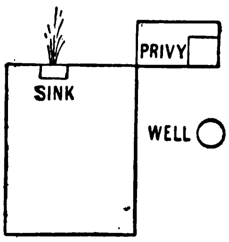


CASE 2 FIG. 1 SCALE 1/500

CASE 3. — A sister in this house had an attack of moderate severity the year before. Family careful to keep their premises clean. Sink-water carried at least twelve metres or more down hill. House on a hill sloping off in every direction. Soil gravelly. The well is deep, lower two-thirds through rock. Privy empties into barn-cellar, five metres or more from well; this they looked after carefully, using earth, &c. They could not be convinced that the well could be affected by it: I suspect it. No bad taste. Manure from horse and cattle in barn-cellar.



CASE 3 FIG. 2 SCALE 1/500

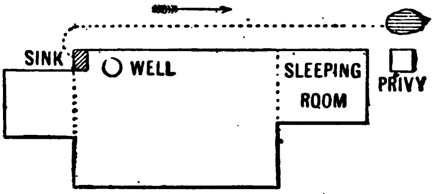


CASES 4-8 • FIG. 3 SCALE 1/500

CASES 4, 5, 6, 7, 8. — I report this family together. First case occurred in oldest son, who came from Cleveland, O., with the fever developed. A severe case. The

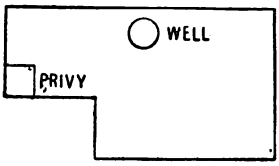
others came down, one after another Well shallow, near the house, and within four and a half metres of the privy. Ground low, level, and saturated with filth. Slops flowed over surface of ground. Vault not tight. I think the water was infected by the first patient.

Case 9. — Severe case. No other in the house or near it. Water supposed to be good; no bad taste. Privy-vault of loose stones, within a short distance of rooms occupied by patient, and about fifteen metres from the well. Sink-sewage runs a little way in an open trough, and the remainder on the ground, to the rear of the privy, where it formed an offensive pool. Odor from it distinct in patient's room in hot weather. Barn not near. Soil loamy. House old, and soil about well saturated at times with sink-water.



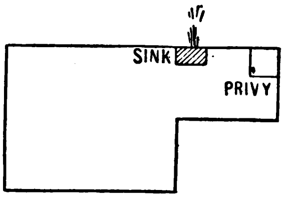
CASE 9 FIG. 4 SCALE 1/500

Case 10. — Severe case. No other in the house or near it. Well five or six metres from privy. No stable. Soil gravelly. No bad taste in water. Other points not noted.



CASE 10 FIG. 5

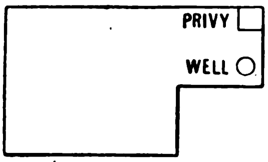
Case 11. — Fatal case. This woman had typhoid in 1870. No other case in house or near. Well shallow, twenty-eight or thirty metres from sink-spouts, and thirty or thirty-two from the privy. Sink-water runs out over the ground in rear of house, under kitchen-windows, and is offensive. I can hardly think the well is affected by it, much less by the privy. Soil gravelly, sloping suddenly in rear of house to a level meadow in which the well is situated.



CASE 11 FIG 6

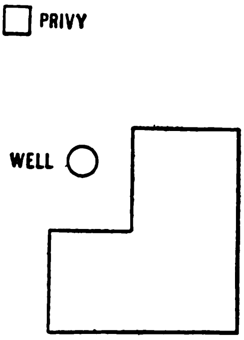
Case 12. — Severe case. No other in the house. Husband of this patient had a well-marked feverish attack, with high tem-

perature, but it passed off without a regular "run." (Case 13, taken about the same time, was about fifty metres distant.) Nothing unusual about the taste of water. Well artesian or "driven," and within four or five metres of the privy-vault, which is not tight. Soil gravelly, porous. Ground level; other points not noticed.



CASE 12 FIG. 7

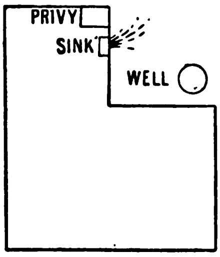
CASE 13. — Mild case. No other in the house. Well near back-door, in ground more or less saturated with slops and kitchen-refuse, though most of the sink-water goes in another direction. Privy ten metres or more from well. Soil loamy. Ground level and low.



CASE 13' FIG. 8

CASE 14. — Mild case. Taken sick in another house, the sanitary condition of which I did not learn.

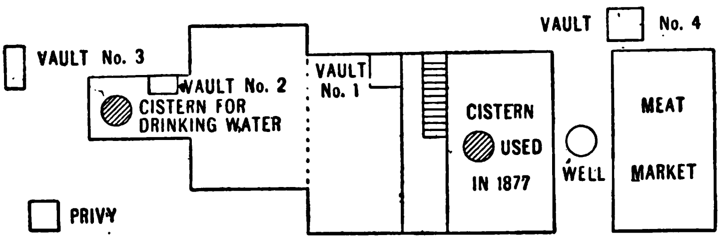
The cases 9, 10, 11, 12, 13, 14, all occurred in 1876. None of them had been exposed to other cases of typhoid. None of the persons exposed to, or taking care of, these patients, contracted the disease.



CASE 15 FIG. 9

CASE 15. — There were no other cases in the house. Cases 16, 17, and 18 were within a hundred and fifty metres. Another typhoid patient, under care of another physician, was within one hundred metres. No communication between the families. This patient, her two brothers, and mother had diphtheria in June, 1877, one brother, aged eight, dying on the nineteenth day. This patient had typhoid-fever in this house in November, 1871. Well ten or twelve metres in depth; upper part through gravel, lower part through solid rock. Water tasted and smelt bad, was quite low; always has had a peculiar taste. No analysis. Privy-vault of loose stones, within six metres of the well. The vault and the well have both been used for fifty years. Kitchen-sewage flows over surface of ground near the well. Cellar dry and clean.. Stable new. Its cellar receives the manure from one horse and a privy. It is twenty metres or more from the well, and lower than its top.

CASES 16, 17, and 18. — Cases 16, 17, and 18 were all in one house and family. The first floor of the main part of the building is used for a store. The upper story has two tenements, the L another. There are *four* privy-vaults about the premises. Vault No. 1 is large, made of irregular-shaped stone, cemented; it is in the *cellar*, which underlies the whole of the main building; but a part containing this vault is separated by partitions from the rest of the cellar, and used for storage of wood and coal. The privy-closet over this vault opens from the back-entry. The kitchen of the family is over this entry and privy-closet, and is connected with it by stairs. The odor from this vault penetrated the whole building, particularly in the warm nights of summer, when the

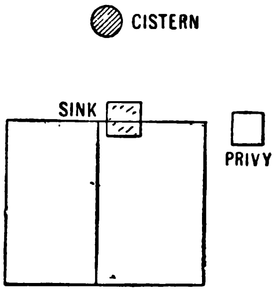


CASES 16-18 FIG. 10

store was necessarily shut. Cases 16 and 17 were taken sick near together. Immediately on seeing them, I had vault No. 1 emptied, and filled with dry earth, sprinkled with chloride of lime, and fumigated with sulphurous acid; also fumigated the house. Also directed the family to get water from a distant source, and use no more from the cistern under the store, from which they had been using. In spite of this, the mother of patient No. 17 was taken sick Sept. 20; also two of her children, aged five and seven, had *malaise*, not amounting to a run of fever. In the tenement, the other side of the entry, I had a case of typhoid in 1872. In 1875 another physician had two cases in the L. At that time there was a vault (No. 2) under the floor of the shed, in immediate proximity to the cistern, which was used for drinking. This vault has since been disused and filled. In this L, I had a case of *croup* last July, fatal in thirty hours. Although there was certainly no false membrane in the throat, the query arises whether it might not be diphtheria. Vault No. 3 is disconnected from the building. Vault No. 4 is in immediate proximity to this building and the meat-market. It is of brick, cemented. A well is within five or six metres of it. None of my patients of this year used this well: they used cistern-water from under the store. Just how far this cistern was from vault No. 1, I cannot say.

Case 19. — Mild case. Premises in best condition. No suspicion of contamination of well from water-closet or any other source. Patient had recently returned from a vacation in New Hampshire, where I suspect she contracted the disease.

The reporter of the foregoing cases adds the following: "During the eight years ending with 1877, I have attended forty cases of typhoid-fever. In eighteen the sanitary influences were not noted. Of the remaining twenty-two, in sixteen the surroundings were *decidedly bad*, the drinking-water being undoubtedly contaminated by being leached through a soil impregnated with human excrement, foul sewage, or both, or (as in cases 16, 17, and 18) the air poisoned by emanations of a huge privy. In four the conditions were suspicious, but not so marked. In one the patient was taken sick in another house, whose condition was not ascertained; and one had returned from another State just before the beginning of her illness. Of these cases, three were fatal. These forty cases occurred in thirty-seven individuals, three having the disease the second time under my own observation; and two of them died in their second attack. I have no doubt of the diagnosis, the symptoms being as well marked as we ever see them."



CASES 20-21 FIG. 11

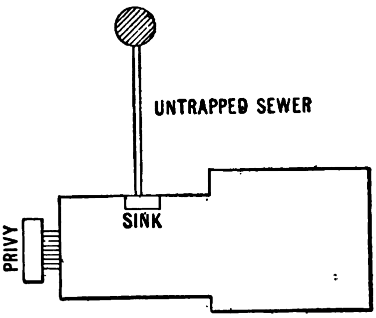
Cases 20, 21. — Sisters living with their parents. A younger child probably had a mild form of fever at the same time. *Cistern-water* obtained from a *sunken hogshead* within dangerous distance of sink-sewage, and possible reach of privy. Privy has no vault; shallow receptacle with board sides. Sink-water runs into a hole with board walls, partly under the sill of house, and distant not more than five metres from cistern. Privy about ten metres from cistern. Cellar in fair condition. No stable; soil, deep sand. Surface of ground at cistern slightly above the sink-hole and privy. Bottom of cistern lower than bottom of sink-hole. House had not stood on this site more than eighteen months.

Case 22. — Probably brought from Cape Cod, where he had been about fourteen days before.

Case 23. — Had nursed No. 22 (her son). Could not be induced to take fresh air or suitable food, and precautions. Came down with fever during son's convalescence, but got about the

house in about a fortnight. She probably never drank water except in the form of tea; but may have become infected while attending the son.

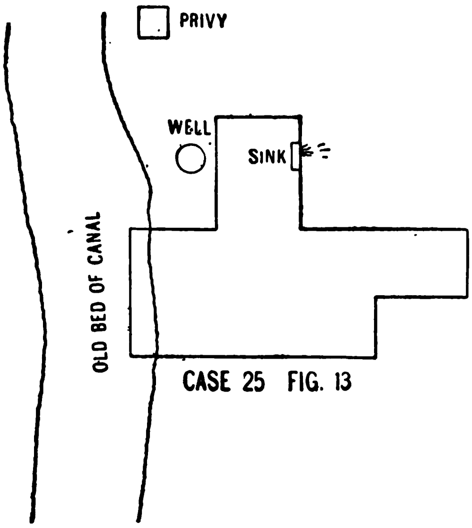
Case 24. — No other case in house or neighborhood for months before or since. Taken sick at home, and no reason to suppose the disease to have been received elsewhere. Water-supply, aqueduct water, from Highland reservoir on hills east of Winchester Village. Water-shed free from any chance of pollution. Privy in rear of house, with slatted air-space between. Vault bricked and cemented, with no odor perceptible in rear part of dwelling. Sewage from kitchen-sink carried under ground to close cesspool at *c*, ten metres west of dwelling. Short ventilating shaft in cover of cesspool. No trap at sink or in sewer-pipe. Cellar dry and well ventilated. No stable. Soil gravelly. Site a high level; no water-course near; all neighboring slopes fall away from dwelling. Family wealthy, and no unwholesome condition detected or suspected, save the *untrapped sink-pipe*. This I believe to have conveyed sewer-gas thus: During the cool autumnal nights the temperature of the kitchen (with windows closed) was several degrees above that of the outer air, which had, by the ventilator, free access to the cesspool; and accordingly a current of air was drawn into kitchen from cesspool, through the sink. *A foul smell had been noticed in the kitchen before breakfast for several weeks.* Patient had prepared breakfast, in absence of servant, for a fortnight before her illness; and thus got every morning a full dose of the poisonous gas in a close room, on an empty stomach, and at the most susceptible age.



CASE 24 FIG. 12

Case 25. — Patient worked in an ice-house when taken. Well-water considered good. Privy "as usual in country villages." House-sewage passed from sink through a spout to the ground, descending to a level with bottom of cellar, about four metres from the cellar, and eight metres from well. Emitted considerable odor. Cellar damp, and at times containing water. No ventilation, except through some broken panes of glass in cellar-windows. House situated on the site of the old Middlesex Canal. Soil sandy.

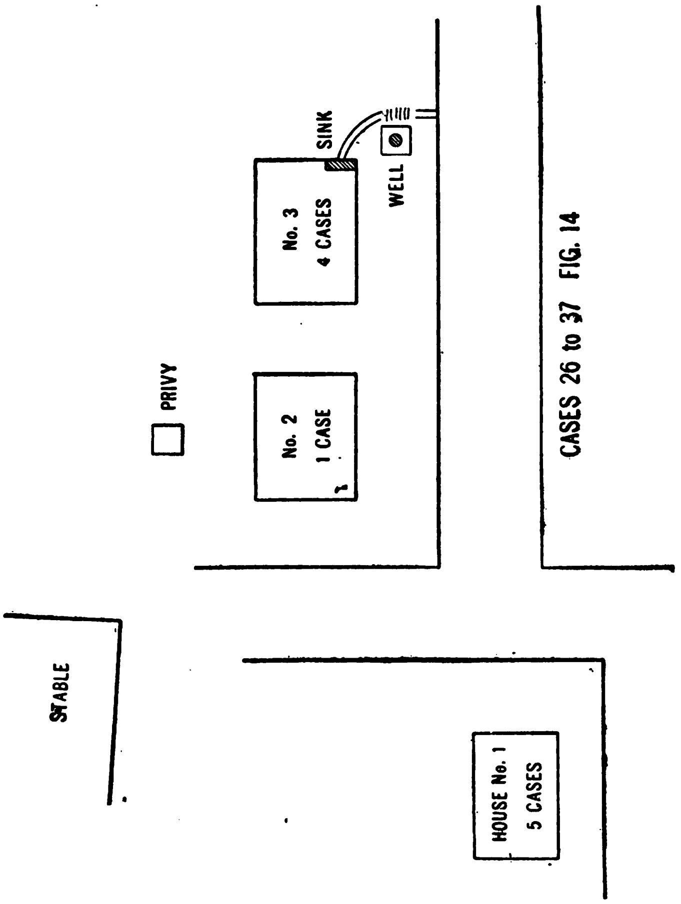
Cases 26 to 37.—This group of cases occurred in the spring and summer of 1872. At that time there were several houses, nearly new, on a short court, occupied by Irish families. In house No. 1 there were five cases of typhoid; in No. 2, one case; in No. 3, four cases. At the same time there were two other cases nearly a mile distant from this locality, both of which were in men who had worked in this neighborhood every day. All of these cases, twelve in number, together with others in the practice of other physicians, acknowledged having drank water from a well directly in front of house No. 3.



CASE 25 FIG. 13

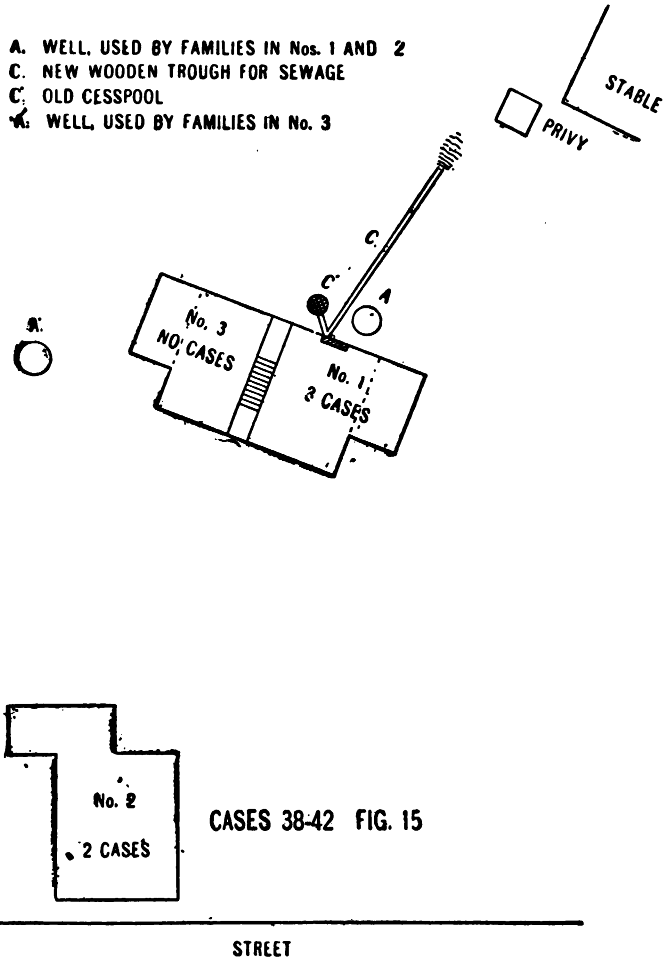
Cases 26, 34, 35, 36, and 37 were school-children, who often drank of the water on their way to and from school, and also while at play in the neighborhood. Cases 27, 28, 29, 30, and 31 were in families who lived near the well, and depended upon it for their water-supply. Nos. 32 and 33 were a mechanic and a teamster, who often drank of the same water during the day, and returned to their homes at a distance at night. This well was supplied with a wooden pump, and was but a short distance in front of house No. 3. The privy was at a remote distance in the rear of the house. The sink-drain was originally intended to run by the well to the opposite side of the street, but had broken just opposite the well-platform and within a half-metre of it, where an excavation had been made by the flow of the sewage, so that the *entire amount of sewage disappeared at this point*. In examining the premises shortly after the first family were attacked with fever, I lifted the trap-door in the well-platform, and saw the filthy bluish stream of sewage flowing over the stones of the well and down into its water. The local board of health was immediately notified of this condition of affairs, and obliged the owner to construct a tight drain, leading by the well to a safe distance on the other side of the street. This well had been dug during the previous season, in a loose, gravelly soil; and the ground being frozen during the winter doubtless prevented the sewage from entering the well; but, as soon as the ground thawed

in the spring, the neighboring families got a terribly-polluted water-supply. As far as could be ascertained, there were no other cases of typhoid-fever in the town at this season, other than those occurring in individuals who acknowledged having drank of the water of this well at some time previous to May 15, 1872.



Cases 38 to 42. — This group of cases occurred at Lynnfield Centre, in September and October, 1877, a very dry season: wells in many places in town had no water. In the north end of the house No. 1, lived a family consisting of an elderly lady, two daughters, and a son-in-law, all of whom except one daughter were taken with typhoid-fever. In the immediate neighborhood was a family who used water from the same well, their own well having become dry. In this house (No. 2), a father and son had the fever; the son's being of a light form. The remaining cases

were long and severe, averaging forty-five days each. The well used during the month of September by these two families was directly in the rear of the house, and very near it. The sink-sewage was conveyed away to a distance of fifteen metres, by an apparently new wooden trough. The cellar was dry, and in good



CASES 38-42 FIG. 15

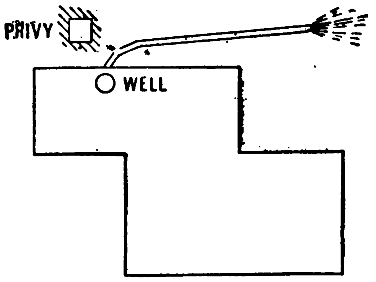
condition. The stable was at a distance of about twenty metres, and privy about the same distance. The sanitary condition of affairs immediately surrounding the premises did not at first appear to be censurable. But on closer inspection I found an old cess-pool which had been used for many years. It consisted of a hogs-head sunk in the ground, which, from decay and offensive odor,

had just been discontinued at the date of beginning of the first case of fever. The ground about the cesspool and well was level, and the distance between this old cesspool and the well not more than three metres. The soil was a light, sandy loam. The water in the well was low, much lower than the bottom of the hogshead, and hence inviting the sewage downward to its own level.

It should be stated also that the family living in the south end of the double house (No. 3) used water from another well (A′), and in this family there were no cases of fever.

Cases 43, 44. — These were two children, aged five and eight years. Symptoms well marked. Each one ill about four weeks. House nearly new; soil compact, clayey. Site on the south side of a hill containing a large quarry of serpentine rock. Sink-sewage flows upon the ground north of house. Privy north-east of house, well south-east, both the former being up the hill and above surface of latter, the general direction of slope towards the well. Distance from well to cesspool and privy not measured; not over twelve metres.

Case 45. — Patient, a married lady, aged about thirty-six; taken ill with typhoid-fever in November, 1879. A child was ill with the same disease in this house in September, 1875. House a comfortable farmhouse about forty years old; on the eastern slope of a rocky hill. Well underneath the wash-room floor. Privy situated on an elevated bank, just outside the wash-room door. Vault a simple excavation in the earth. Ground sloping rapidly from the privy toward the well, which is not more than four metres distant. Sink-water conveyed away from house in a long wooden trough. The connection between the sink and the trough had broken, and much of the sewage had run upon the ground very near the foundation of the wash-room, and within two metres of the well. This family used the water of the well for cooking-purposes and partially for drinking. They also used for the latter purpose considerable quantities of water said to be obtained from Bethesda spring in Wisconsin. This was used, not from any suspicion that the well-water was bad, but because they believed the Bethesda water to be peculiarly beneficial to their



CASE 45 FIG. 16

health, and therefore purchased it in large quantities. The stable was distant from the house and well at least forty metres, and at a lower level, where it would not be likely to affect the water.

Cases 46, 47, 48. — This group of cases consists of a mother and two children, aged thirty, ten, and eight. All three were of a mild type. The father had a short and sharp attack of pneumonia in the same house in the preceding summer. Suspicions of local infection. I found on inspection the following condition of affairs: Soil a loose, dry gravel, overlaid with sandy loam. House about thirty years old. Well at south-east corner of house, one metre from the house. Water in it very low, and tasting badly. Privy eight metres distant from well. Cesspool north of house and six metres distant from well. This cesspool was nearly dry, and had apparently received no sewage for a long time. There was no cellar under the kitchen, only a shallow space between the floor and the earth. On gaining an entrance to this space, I found that the sink-spout had become disconnected just below the floor, and a large pool of sewage had collected on the ground, covering most of the space under the kitchen, and extending across to within a metre and a half of the well. The surface of the water in the well was very low, at least five metres below the pool of sewage.

To these cases the reporter adds the following note: "These cases (from 26 to 48 inclusive) comprise about two-thirds of my cases of typhoid-fever, from 1872 to 1879. In the remaining third, evidence of neglect of sanitary precautions was not found; and, in some of the earlier cases, the observer pleads guilty of superficial observations. No. 45 was not included in the report to Middlesex East Medical Society, above alluded to, since it occurred after the date of that report."

The foregoing summary of cases comprises at least one-half of those occurring in the practice of the physicians referred to. In the cases detailed above, the existence of conditions which would necessarily presuppose contamination of water-supply, and in many of them the actual detection of such contamination, together with the existence of typhoid-fever, can hardly be considered a simple coincidence; especially when, as in the outbreak alluded to in cases 26 to 37, no other cases of typhoid were known to have occurred in the town at the time, other than those who had acknowledged drinking the water of the polluted well. Is it not more than probable, that, in the remaining cases in the same towns, similar contamination existed, though unobserved?

The few cases here detailed occurred in only five towns of this State, embracing, in all, about one per cent of its population, and were but a portion only of those which occurred within the limits of those towns; and yet they represent a loss to the State of seven individuals by death, and at least twelve hundred days of actual time.

RECAPITULATION.

The majority of the cases referred to in the above summary (seventy per cent) occurred in groups of two or more, as is common to this disease.

The following points are also noticeable: —

The drinking-water had a bad taste or smell in eighteen cases.

The well was in dangerous proximity, either to the cesspool, the privy-vault, or the stable, in twenty-two cases.

The soil in the immediate vicinity of the well was saturated with sewage in twenty-seven.

There was a damp cellar in two cases.

There was a faulty construction of the privy-vault in fifteen cases.

The foul odor of sewer-gas was detected in the house in seven.

The soil in the neighborhood of the well was of such a nature as favored sewage saturation and percolation in eighteen cases.

There was a broken sewer near the well, causing pollution of the water, in sixteen cases.

In twenty-seven cases there had been one or more previous cases of typhoid-fever, either in the same house, or in its immediate vicinity.

Contamination of the drinking-water was ascertained to be the fact in more than one-half of the cases reported, and was also a matter of probability in a portion of the remainder.

Attention is specially called to some of the cases occurring in groups.

In the first group, comprising cases 4, 5, 6, 7, and 8, there was a marked neglect of sanitary precaution in the location of the well and vault, and also in the disposal of sewage and filth.

In the group comprising 16, 17, and 18, there was a crowding together of tenements, together with meat-market, well, cisterns, and vaults, not altogether unusual in the neighborhood of old buildings such as have undergone various processes of alteration and repair in country villages without a general water-supply. If the prevailing opinions in regard to the causation of filth-diseases are correct, we should naturally expect the continual occurrence of disease in such a locality.

In case 24 the important point appears to be the want of a suitable trap in the sewer.

In the group of cases, 26 to 37 inclusive, it is worthy of note that all cases of typhoid-fever which occurred in the town at that season of the year, whether in the immediate vicinity of the contaminated well, or at a remote distance from it, acknowledged having drank water from the same well within a short time previous to the invasion of the disease. There was sufficient evidence, both to the sight and smell, of serious pollution of this well with sewage.

The cases included in the foregoing report are not presented for the purpose of illustrating either of the prevailing theories in regard to the causation of typhoid-fever, nor do they represent an unusual epidemic or peculiar form of disease. They are simply selected from the ordinary routine of practice of physicians living in country villages, suburban towns, and farming districts. Material for a similar report could doubtless be collected from an equal number of population living under similar conditions in any part of the State.

The necessity of a more thorough supervision of the location of wells, with reference to the points already mentioned, in towns without a general water-supply, is apparent.

The early introduction of a pure water-supply, with adequate sewerage in all large towns in the State, is a matter of prime importance. If the completion of such works should be attended with results similar to those witnessed in many cities of England and Wales,[1] we should be enabled to record a decided diminution in the mortality from typhoid-fever within the following ten years, and a consequent gain to the State, which could scarcely be reckoned in terms of pecuniary value.

[1] Fifth Annual Report, Mass. State Board of Health, pp. 365, 366; Sixth Annual Report, Mass. State Board of Health, pp. 70–72.

TYPHOID-FEVER IN BROOKLINE IN 1879.

REPORTED BY DRS. R. AMORY AND G. K. SABINE.

WE will present the subject under four heads: —

1st, The report of cases by their attending physicians.

2d, The question of season as affecting the epidemic.

3d, A comparison of the present epidemic with cases existing in previous years.

4th, Supposed causes which might influence this epidemic; and this latter subject to be subdivided under the heads of atmospheric condition, food, and water-supply and drainage.

At the outset of our inquiry the following questions were sent to the seven physicians practising in Brookline, and corresponding answers have been received with the following results: —

No. 1. How many well-marked cases of typhoid-fever did you see in 1877?

Ans. Four.

No. 2. How many in 1878?

Ans. Seven.

No. 3. How many in 1879?

Ans. Forty-two. (This number includes four cases that were attended by physicians living out of town.)

No. 4. Please state date of first visit, and probable commencement of prodromata of disease.

Ans. Aug. 14, 1; Aug. 20, 2; Aug. 21, 3; Aug. 25, 1; Aug. 26, 1; Aug. 29, 2; Aug. 30, 1; Aug. 31, 2; Sept. 1, 1; Sept. 2, 1; Sept. 4, 3; Sept. 5, 1; Sept. 6, 1; Sept. 7, 3; Sept. 8, 2; Sept. 9, 1; Sept. 12, 1; Sept. 13, 1; Oct. 1, 1; Oct. 26, 1; Oct. 27, 1; Oct. 30, 1; Nov. 3, 1; Nov. 4, 2.

The exact date of the first visit upon the remaining seven cases was not given; but they were all made during the month of August, with one exception. Prodromata extended over a period of from three to fourteen days.

No. 5. How many cases of other fevers, such as are commonly called "slow," "continued," or "relapsing," have you seen during the same year?

Ans. Twenty-two.

No. 6. How many of the cases of typhoid-fever (according to the different years) apparently originated in Brookline? and where had each one of the patients been during the previous three weeks?

Ans. Of those occurring in 1877, three originated in Brookline. Of those in 1878, three originated in Brookline; one not stated. Of those in 1879, thirty-seven originated in Brookline.

No. 7. In what parts of the town have the cases occurred which were seen in 1879?

Ans. Four each in Juniper and Pearl Streets; three in Fay Place; two each in Clyde Street, corner Carlton and Colchester Streets, Gorham Avenue, corner Howard Avenue and Park Street, Walter Avenue and Washington Street; one each in Pleasant, Carlton, Cypress, School, Park, Babcock, St. Paul, Walnut, Dudley, Prospect, North Beacon, Vernon, and Kent Streets, Summit Avenue, Davis Avenue, Howard Avenue, Morss Avenue, Brookline Avenue, and Harrison Place.

No. 8. What has been the source of their water-supply?

Ans. All of those originating in Brookline, except three, used the water supplied by the town; of these three, two used well-water that was contaminated by decomposing animal and vegetable matter.

No. 9. What has been the source of their ice-supply?

Ans. Of those using ice, the greater number used that supplied by the Jamaica Pond Ice Company.

No. 10. What has been the source of their milk-supply?

Ans. Various sources; a large proportion using milk from their own cows.

No. 11. How is the sewage disposed of from the houses in which the cases occurred?

Ans. From one-quarter to one-third are connected with the public sewers; the others with cesspools, very few of which are ventilated.

No. 12. How many of the above cases terminated fatally?

Ans. Six.

We append a detailed report of the houses in which were twenty-three of the sixty-four cases of the fever, chiefly from an analysis of the replies of physicians to the circular already mentioned. There are many houses in Brookline where the sanitary arrangements are as bad, and even worse, than these in which cases of typhoid occurred. We regret that we are unable to gather information concerning the surroundings of all the cases.

Case 1. — Patient lived in a wooden block on Washington Street, near the junction of Boylston, the first story being used for shops, the second for living-rooms, and the third for sleeping-rooms. Water-closet on first floor. Sink in small kitchen in second story, which drains into sewer. No trap in sink-drain, except bell-trap. Drains leaky in cellar, and not ventilated. No fixed bowls in house.

Case 2. — Servant in a house which is situated on one of the highest elevations in Brookline. Sewage-matter is drained into a series of cesspools. Drains in themselves perfect and well trapped, but not ventilated. Basement kitchen, no set bowls. Patient slept in a large, airy room, in the first story, and in that part of the house farthest removed from the kitchen. Water-closets in second story and basement.

Case 3. — Occurred in a family living in the second story of an old house, situated on the very low ground nearly opposite the railway-station. That portion of the house occupied by the family consists of three rooms, — a kitchen and two sleeping-rooms. Sink in kitchen is drained in a running brook which has been covered over, and thus converted into a sewer. No traps in drain. Privy is outside of house, situated over brook, a little below where sink-drain enters.

Case 4. — Occurred in the second story of a new house on Walter Avenue, which is on rather low ground. Family occupy four rooms, — kitchen, sitting-room, and two sleeping-rooms. Sink in kitchen drains into street sewer. Only bell-trap in drain. Drain not ventilated. Water-closet in cellar. Patient's sleeping-room is separated from kitchen by sitting-room.

Cases 5, 6. — Occurred in a small house on Clyde Street. Family occupy second and third stories, — the second being used for kitchen and sleeping-room, and the third for sleeping only. Sink in kitchen drains into privy-vault, which is about twenty feet from house, and this into cesspool. Drain, which passes from sink through the wall, and down outside of the house, only trapped with a bell, and not ventilated, but quite leaky. Patients usually slept in third story. The well from which the patients *sometimes* drank was found to be very foul, owing to the presence of a dead rabbit and a large quantity of decomposing vegetable matter.

Cases 7, 8. — Occurred in the same house with No. 3, but two months later.

Case 9. — Washington Street. Family gone. Cellar was very foul; sewer connection; sleeping-room door about eight feet from water-closet door, the latter having no ventilation except into the entry; soil-pipe unventilated.

Case 10. — Davis Avenue. Nothing wrong with water; water-closet has open window, soil-pipe not ventilated; sleeping-room next to it at right angle, and door open. In cellar of shop in which the patient worked, the drain was broken, and there was a very offensive smell from it; the cellar-door was usually open, and close to the workbench.

Case 11. — Juniper Street. Bad taste and smell of water; no sewer; privy cleanly; stable for five cows about eighty feet off, and during summer foul and stinking.

Case 12. — Water quite bad; cesspool and soil-pipe not ventilated; bath-room and water-closet in an L remote from sleeping-rooms and with open window.

Case 13. — Sanitary arrangements good; nothing wrong noticed with water; child thought to have become ill away from home.

Case 14. — Servant ill; water seemed good; sanitary arrangements excellent, except that cesspool was in use for water-closet.

Case 15. — Nothing bad noticed about water; sleeping-room door close to door of water-closet, which empties into cesspool, with unventilated soil-pipe.

Case 16. — A house on the corner of Colchester and Carlton Streets, at an elevation about ten feet above the latter street, ground sloping from house to street. Until the spring of 1878, all the sewage from this house passed into a cesspool fifty feet distant from its rear wall, and the top cover of which is about six feet lower than the sill of the back door. In April, 1878, the cesspool, after being thoroughly emptied, was filled with dry and sifted coal-ashes, and covered with loam and grass, and the old drain (of brick) broken up and removed. A new drain of earthenware pipe was then laid, and connected with the main sewer on Carlton Street. One year previous to this date an old lead soil-pipe had been replaced by one of cast-iron, and a ventilating lead pipe between each trap communicated with the outer air by a ventilating iron shaft at a height three feet above ridge-pole of the house. Two Jennings water-closets were also put into this house, and there is no plumbing of any description in the main part of the house. A bath-room with an outside window is in the L at an elevation of four feet below the chambers. A water-closet is in the L, with a window in it on the outside wall of the house. There is also a hopper water-closet in a shed outside the kitchen, shut off from the sewer by a trap ventilated between it and the closet. The drains have been tested several times by oil of peppermint, which showed no leak. All the joints of the iron soil-pipe were tightly calked with cold lead, and then covered over with red lead paint.

Case 17. — A house opposite the one just described, commnuicat-

ing with main sewer on Carlton Street by an iron pipe with calked cold lead joints within house and cellar, and an earthenware pipe outside of house wall. This work was completed in September, 1878. Prior to this time the sewage of house was carried by same iron soil-pipe to a cesspool fifty feet from this house, the cover of which was ten feet below sill of kitchen floor. The soil-pipe, but not the traps, is furnished with vent-pipes, and the soil-pipe communicates with the open air through the roof. There is one bath-room with its water-closet, where the L of the house joins the main house. This is the northerly half of a double house, that on the south being constructed on the same plan. In the house where this case occurred, there is a water-closet in a tight unventilated closet directly under the bath-room above described. This water-closet is that pattern called the Bartholomew valve closet, receiving its supply of water directly from the main water-pipe of the house. At the time of inspection it was so much out of order that scarcely any water would flow into the pan or its receiver when the handle was lifted. As neither the closet, nor trap, nor receiver, was furnished with vent-pipes, it was a source for the disengagement of sewer-gas into the back portion of the house. There was no plumbing in the main part of this house, but the air from the L had free communication with the front entry. The L was one story high, and the main house two-storied with a French roof. The patient had been sleeping in the upper or French-roof story main house.

CASE 18. — The easterly lower tenement of a double house whose rear wall is about forty feet from a filthy tide-water stream called Muddy River. There was no water-closet in this house, a privy-vault in an outhouse in the yard receiving all the excreta of this and the inhabitants of a tenement above that in which this case of typhoid-fever occurred. The only plumbing in this house was an iron sink in a kitchen in rear of the room in which the patient slept. This sink had an outlet into an earthenware drain running into a trap, and discharging directly into Muddy River. The patient was a day-laborer on a gentleman's place, and slept and took his meals in his mother's house. Neither his mother nor sister, who passed almost all their time at home, had any signs of sickness, and had lived there for five years; nor was there any sickness in the members of the other three tenements, whose sanitary arrangements were precisely similar.

CASE 19. — A large, well-ventilated house on Kent Street, the location being almost the highest elevation in this part of Longwood. There was no town-sewer within six hundred or more feet of this house. All the excreta and drainage were received into a cesspool fifty feet from the south side of the house: the members of the family sleeping on the north and east sides only. All the

plumbing of this house is in the L, and the patient slept in a room separated from this L by a large, airy chamber and a closet. The cesspool was emptied every few weeks, and its contents deposited in a meadow nearly a thousand feet from the house. The stable is five hundred feet distant, on much lower land. The soil-pipe is of iron, having an opening above the roof, with calked iron joints, but is unprovided with other vent-pipes, and the drain-pipe between house-wall and cesspool is not trapped. It is not impossible that sewage-gas could have escaped through the water-closets, or basin traps; but still this house has sanitary arrangements superior to the average of the country houses that have been inspected by the reporter.

CASE 20. — A house on Pleasant Street, far removed from any town sewer. A new cesspool had been constructed last spring in low land about eighty feet from the nearest point of cellar-wall. The cellar of this house was suspiciously damp, and the soil-pipe built of earthenware was laid in the earth. So far as examined it did not leak, nor could any smell of sewage-gas be detected. There were two bath-rooms with water-closets in the upper story of this house, and the soil-pipe, though constructed of iron above the cellar, had no vent-pipe, or communication with the outer air above the roof. The patient slept in an upper room, on the north side of this house, but his chamber was off an airy hall-way, and no communication with either bath-room except through this hall. The house is on a level with the street, but much higher than the land behind and at its side. The main water-pipe leaked in the cellar, and may have caused the dampness noted. The patient had a bad habit of sitting up late at night on the piazza, and had frequently been warned that he was exposing himself to the night dampness. He was a salesman in a seed-store in Boston, and passed his evenings and nights, and ate dinner at noontime, in this house. None of the other inhabitants of this house showed any symptoms of malarial disease.

Here we have forty-two cases of typhoid-fever and twenty-two of "slow or continued" fever, which we will class under the head of mild typhoid, occurring during a period beginning early in August, or at the close of July, and extending to November, or of about three months duration. The population of Brookline is from the latest census 6,675, and probably during the months of August and September very much smaller, owing to the absence from their homes of about one-tenth of this population, leaving the number of about 6,000. Thus we may suppose that the number of cases actually reported to us bears the numerical proportion to the resident population of one per cent; and of this total number of cases ten per cent terminated fatally.

It will be remembered that August, September, and October are the most common months for the existence of typhoid-fever. Now, the weather during these months in 1879 might be roughly analyzed in the following manner. From August to the 21st of September the temperature was unseasonably cool, and after that date no very excessive weather was recorded; the season was peculiar only in the fact of unusually prolonged summer weather, and as having rather an excessive saturated moisture in the atmosphere.

In order to ascertain if this season was specially marked as one predisposing to an epidemic in towns near Brookline, we addressed letters to physicians in Walpole, Watertown, Jamaica Plain, Newton, Dorchester, Dedham, West Roxbury, and Cambridge. The letters in answer do not indicate that there had been any unusual number of typhoid-fever cases in any of these places. These replies are presented here as follows: —

S. E. Stone, M.D. (Walpole). I do not know of a case of typhoid in my neighborhood, or in this town, and we very seldom have any. It is very seldom that a permanent resident has the disease, and it is still more so that any thing like an epidemic of it occurs.

Alfred Hosmer, M.D. (Watertown). I can give you no information on the subject of typhoid, as I have not seen a well-marked case this year, and only one such leads me to the belief that the patient had typhoid in a very mild form.

J. Stedman, M.D. (Jamaica Plain). We have had no typhoid originating here during the summer, and only two cases in September, both of which undoubtedly originated away from here and came home sick.

L. R. Stone, M.D. (Newton). I have heard of but two cases of typhoid-fever in Newton, that is, in that part of Newton called the "Corner" and Newton Centre. I have seen no case in my practice.

C. Ellery Stedman, M.D. (Dorchester). I have seen only two cases this year, both of which originated away from home.

J. W. Chase, M.D. (Dedham). There have been no typhoid-fever cases on the Charles River, either in Dedham or West Roxbury, this summer, in fact, only two or three cases in all Dedham.

J. L. Hildreth, M.D. (Cambridge). I have been to the City Hall, and secured from the principal health officer the following facts: One year ago (1878), from the first of August to the last of October there were twenty-one cases reported, with four deaths. This year (1879), during the same month there were twenty-five cases reported, with one death. Several of these were reported as "imported," and several were in the same house where there had

been cases before. In July of this year (1879), there were seven cases, in August seven, in September nine, and in October nine. From Jan. 1 to July 1, there were five, making a total this year, from Jan. 1 to Nov. 1, of thirty-seven. In November, 1878, there were four cases, and the same number in November, 1879.

The natural conclusion from the information thus presented would be that we had an unusual epidemic of typhoid-fever in Brookline. There was very little diarrhœa during the year, less even than usual.

So far as modern medicine would enlighten us, the influences which predispose to an epidemic of typhoid-fever belong to atmospheric conditions, personal contact with persons who have this disease, or with their excreta, imperfection of house-drainage outlets, pollution of drinking-water, milk-supply, and food, or imperfect soil-drainage in or near the local habitation of the patient.

In the course of our investigation we found that generally the cellars were well ventilated and comparatively dry. A reference to the accompanying map will show that the cases were distributed throughout the town except in the highest locations, if we exclude Clyde Street, where there was an unclean well from which drinking-water was obtained. In only a very few instances were there more cases than one in each house.

With three exceptions, all the patients drank water supplied by the town water-pipes. Of these three exceptions two cases occurred in the house using a contaminated well on Clyde Street. As this question of water-supply was one common to all the cases except one, we instituted a very careful investigation of the purity of the water supplied by the town. This investigation was based upon the results of chemical analysis and of the personal inspection of the source of water and its method of distribution.

In 1875 the town built a filtering-gallery near the Charles River (Cow Bay) in the town of West Roxbury, and laid earthen pipes along a marsh from this filtering-gallery to a pump-well situated about three or four thousand feet distant. For about half the year this marsh is covered with water. In the fall of 1876 the earthenware pipe was found broken in several places, and it was replaced by a wooden conduit which it was supposed would be practically tight, and would keep out the swamp-water.

In the spring and summer of 1878 this wooden conduit was discovered on inspection to be very leaky, allowing swamp-water to pass through the tongued joints.[1] In the spring of 1878 a water-

[1] It is proper to state that this leakage was discovered after the conduit had been subjected to frequent flushings under the heavy pressure of a head of water effected by a reverse current from the action of the condensing-

closet was built connecting with the hot-water discharge-pipe of the condensing-engine used to pump this water up to a reservoir and to the main supply-pipe in Brookline. This water-closet was used nearly every day by one or two men employed at the pumping-station. The hot-water pipe discharged into a small, irregularly bounded creek running parallel with the wooden conduit, and about fifteen or twenty feet from it. About fifty feet from the outlet of this hot-water discharge-pipe, the creek debouched on to the low land directly over the wooden conduit; this end of the conduit was about six inches lower than its origin at the filtering-gallery.

We inspected these water-works for the first time on the 11th of September, 1879. At that time we could trace the water from this creek finding its way through holes in the ground down into the soil over the wooden conduit not seventy-five feet distant from the pumping-well of the stationary engine. On opening the manhole (over the gateway) nearest to the pump-well, about fifty feet distant, the smell of decomposing vegetable and organic matter was noticeable. We next visited the filtering-galleries near the river. The only possible chance of pollution of these galleries could be that of sewage from houses situated a thousand feet or more distant, and the natural drainage of which was in another direction, or towards the river, and from a house and farm on a high gravel-bank, situated almost at the same distance on the opposite side of the filtering-gallery. The chance of sewage flowing into the marsh containing the conduit was almost insignificant, except as above described.

An inspection of the drinking-water used by some families in our town from this supply showed a bad color, odor, and taste, which had been noticed during the summer months of July, August, and September, and had been attributed to the decomposition of a fungoid growth which accumulated in the wooden conduit. In other families the water seemed perfectly pure the whole season. The water in the creek, which had received the discharge of five thousand gallons of hot water per day and the excreta of three men, had a temperature on the day of our second visit (Sept. 14) of 117° F.

With this view Professor Farlow of Cambridge examined microscopically fresh samples of water taken from the creek, the conduit, and the pump-well, but with no positive information that would lead to any practical result. We also sent Professor E. S. Wood, M.D., of the Harvard Medical School, several samples of water, and present the following table of the results of his analysis.

engine, and that this mode of treatment was never contemplated by the engineer who superintended the construction of the conduit.

Brookline Water Analysis.

[Figures express parts per 100,000 of water.]

	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Residue.			Hardness.	Microscopic Examination by Professor Wood.	Remarks.
				Fixed.	Volatile	Total.			
1.—From public fountain in Harvard Square, Sept. 9, 1879	0.0008	0.0140	0.90	4.00	4.25	8.25	4°	- -	Slight charring.
2.—From faucet in house in which there was a case of typhoid-fever, Sept. 8, 1879,	0.0000	0.0128	1.00	5.50	6.50	12.00	3½°	- -	Slight charring.
3.—From faucet in house in which there was a case of typhoid-fever, Sept. 10, 1879,	00.000	0.0102	1.10	6.25	4.00	10.25	3½°	- -	Slight charring.
4.—Filtering-gallery manhole nearest to Charles River, Sept. 11, 1879 . . .	0.0026	0.0022	0.60	4.00	7.00	11.00	2½°	No bacteria .	No charring.
5.—From well in pumping-station . .	0.0008	0.0048	1.10	5.00	1.75	6.75	3°	One bacterium perhaps accidental? .	Considerable charring.
6.—Ice left at a house by Jamaica Pond Ice Co., Sept. 11, 1879	0.0240	0.0276	0.70	3.00	9.50	12.50	1½°	- -	Considerable charring.
7.—From second manhole in the conduit 350 feet from pumping-station, 1,300 feet from filtering-gallery, Sept. 13, 1879 .	0.0008	0.0032	0.80	5.00	2.50	7.50	2½°	Bacteria lineola and bacillus ulnea. .	Slight charring.
8.—From manhole nearest (about 40 feet) to the pump-well, Sept. 13, 1879 . .	0.0186	0.0146	0.90	4.50	6.50	11.00	4°	Very few of bacterium lineolum. .	Much charring.
9.—Four inches from surface of water from a dead end of main supply pipe, cor. Joy and Essex Streets, Longwood, Sept. 15, 1879	0.0000	0.0102	0.80	5.75	3.25	9.00	4°	- -	Considerable charring.
10.—From storage reservoir, Brookline, Oct. 3, 1879	0.0080	0.0068	0.70	5.75	3.25	9.00	1.8°	- -	

From the chemical analysis, as shown in this table, it appears that this water is not worse, but even is better, than the average drinking-water supplied by towns and cities in our vicinity; but it is not impossible that the days on which the samples were drawn afforded a better estimate of the water than if these samples had been collected a month earlier. It should be noted in this connection that the pump at the water-works had been in constant motion on Sept. 8, 9, 10, 11, and 12; and when the reservoir and pipes were full the surplus was discharged at a long distance from the pumping-station, through a blow-off on Newton Street in Brookline. On Sept. 13 the engine pumped for eighteen out of the twenty-four hours. Our samples of water, therefore, were taken while the water in the conduit between the filter-gallery and pump was almost in continual agitation. We note, on the other hand, that during the month of July the pumping was very intermittent, as will be seen by the following statement taken from the records of the Water Board: —

The first three days in July, the pump was in action for about twelve out of the twenty-four hours, and from the 7th to the 12th ten hours out of the twenty-four; on the 4th, 6th, and 13th there was no pumping; on the 17th and 18th, continuous pumping for forty-eight hours; on the 19th, for nineteen hours; on the 20th, 21st, and 27th there was no pumping.

However, the conduit was flushed by forcing water by a reverse current from the condensing engine on the 7th, 14th, 22d, and 28th, the water being discharged in the swamp in which the conduit is embedded. In other words, during sixteen days (14th to 29th), the pump was in action only one hundred and sixty-seven hours, forty-eight of which were continuous, viz., on the 17th and 18th: the rest of the time the pumping was intermittent and during only one-third of the time. During the first part of August the pumping was continuous about two-thirds of each day; during the latter half of August, only about one-third of each day. The pump was not in action on the 10th, 17th, 24th, and 25th of this month.

Again in September, the pump was not in action from the 1st to the 6th, and it was during the next few days when the pumping was resumed that the water tasted very badly. This intermittence in the pumping would tend to decomposition and development of organic life in the water on the land near the pumping-station, which leaked into the main conduit, especially when we take into consideration the temperature of this stagnant water.

Hence we infer that the time of taking samples of water was not well chosen, and we simply record these facts without offering criticism.

About the beginning of October a new iron conduit was laid in the marsh at a higher level of two feet, directly over the leaky wooden conduit, and the use of the latter was then discontinued. There still remains, however, a short section of a wooden conduit, laid in a natural gravel-bed for a length of three hundred and eighty-nine feet, which connects the two filtering-galleries. To recapitulate: the filtering-gallery nearest Charles River, and about five hundred feet from its right bank, is four hundred and ninety-one feet in length; next comes the wooden conduit, itself three hundred and eighty-nine feet long; and then another filtering-gallery, two hundred and seventy-one feet in length, connected by an iron conduit with the new pump-well; and from this latter emerges the iron pipe used at this present writing (Feb. 15) as a force main.

A detailed description of the first construction of the filtering-galleries is presented in the "Final Report of the Brookline Water Commissioners, 1875." At the close of November, 1879, a defect was discovered in the original construction of the gallery nearest the river, the effect of which was to obstruct a large amount of the water-supply from this gallery.

It would hardly be proper to omit reference to the general sewerage of Brookline. In the spring of 1877, as may be seen in the town report for the year ending Feb. 1, 1878, the town built a main sewer from Aspinwall Avenue along the Brookline Branch of the Boston and Albany Railroad to the corner of Colchester and Carlton Streets, from this latter point along Carlton to Beacon Street, along Beacon Street to St. Mary Street, which formed the boundary-line between Brookline and Boston, and thence to Charles River. The outlet of the sewer is submerged at all stages of the tide.

The account of the construction of this sewer is so concisely and accurately given in the report above referred to, that it is unnecessary for us to furnish any detailed information, except in reference to those residences which were the *habitat* of typhoid-fever patients. Of the five cases in Longwood, two lived in houses near the corner of Carlton and Colchester Streets. In one of these houses a careful inspection of the house-drains exhibited not even the slightest defect. The cesspool had been abandoned a year previous. In the other there was a defective water-closet; though the patient slept in a room two flights of stairs above the floor where this closet was located.

There are along Carlton Street four man-holes with perforated iron covers, which allow ventilation and escape of gases from the sewer. One of these man-holes is about one hundred feet from

the house with the perfect drainage, and one hundred and fifty feet from the house with defective water-closet.

One more fact in regard to the sewerage should also be recorded. In Longwood, during the summer and fall of 1877, the excavation of the trench for the sewer was attended with so much water that two large steam-pumps were kept in constant motion. This drew off the ground-water so that all the wells near by became perfectly dry. The ground-water in the Longwood district has always been at a low level; and it is more than probable that this level is now lower than before the time the sewer was laid, as no well within five hundred feet of the sewer-line has since that time had any water in it.

TYPHOID-FEVER. — EIGHT CASES FROM ONE WELL.

If the risk is not in all cases great from the contamination of wells by vaults, etc., yet it is often unsuspected, so far as any taste, smell, or appearance of the water is concerned, and may be attended with the most serious results; a striking illustration of which is furnished by Dr. George Atwood of Fairhaven, as having occurred in his experience.

In the latter part of August, Mr. —— was ill with what seemed to be dysentery, but not so as to prevent his keeping about. On the 7th of September he went to bed quite ill, and sent for Dr. Atwood, who pronounced the disease typhoid-fever. In the mean time, his dejections had been passed freely in the privy-vault, which was *one hundred feet distant* from the well (nearly twenty feet deep), and separated from it by it by dry gravel and loam. After this date there were two heavy rains, presumably washing the soluble and fluid portion of the excrement from the vault through the soil into the well, by a channel already formed, or by soakage into the ground-water. The water in the well was very low at the time, and could be all pumped out in a few minutes.

Sept. 30, the wife became ill with typhoid-fever.

Oct. 3, a daughter became ill with typhoid-fever.

Oct. 6, another daughter became ill with typhoid-fever.

Oct. 7, two sons became ill with typhoid-fever.

Oct. 8, another daughter became ill with typhoid-fever.

Oct. 12, another daughter became ill with typhoid-fever.

The youngest boy had the disease in a mild form, so that it is difficult to fix the date of its beginning, further than to say that it was about the middle of October.

That is to say, every person drinking the water from the family well had typhoid-fever, eight in all, within a period of twelve days of each other, and at about the time (allowing for the usual incubative period of the disease) when the well might naturally become contaminated from the vault with the specific poison of typhoid-fever.

An examination of the well-water by Professor Nichols, Oct. 17, showed that it contained, in parts per 100,000: —

Ammonia	0.001
Albuminoid ammonia	0.013
Total solids	20.3
Chlorine	3.3

The residue blackened considerably on ignition; but there was

no re-action for nitrates in unconcentrated water by the ferrous sulphate test.

As the water seemed to contain an increased amount of albuminoid ammonia, total solids, and chlorine, the suspicion of its impurity was confirmed by the examination of another well a few hundred feet distant, probably supplied by the same or a similar source, and not in danger of pollution, from which the results were, —

Ammonia	0.001
Albuminoid ammonia	0.007
Total solids	15.3
Chlorine	2.4

No blackening on ignition, and no re-action for nitrates in unconcentrated water, by the ferrous sulphate test.

In order to ascertain whether there was a direct communication between the vault and well, a bushel of coarse salt was put in the vault, Oct. 24, and a bushel of fine salt, Oct. 31; and the subsequent chemical examinations gave the following results: —

Date.	Amount of Chlorine.
Oct. 26	3.9
" 29	3.9
Nov. 2	4.0
" 5	4.4
" 8	3.5
" 13	3.4
" 17	3.4
" 20. Rainfall	3.3
" 23. Rainfall. Water low in well	3.1
" 26	3.1
" 30	3.0
Dec. 3. Water low	2.9
Oct. 17	3.3

It seems clear that the effect of the salt was directly felt in the well, and that there was abundant opportunity for the dejections of a man ill with typhoid-fever to pass into the water which his family were in the habit of drinking. No other cases of typhoid-fever were known to have occurred in the vicinity during the summer.

Seven persons were ill, and confined to their beds at the same time, in six rooms, constituting all the available space, except the entries and kitchen, in a small house. These seven persons, a boy not ill enough to be confined to his room, and another member of the family treated at a neighboring house, were all who drank the water shown to have been pretty certainly contaminated by the dejections of the first patient, Mr. ——, thrown into the vault, and thence communicating with the well; eight of them were taken

sick within two weeks of each other, and, allowing for the usual period of incubation of the disease, at a time when it might be fairly supposed that the specific typhoid-fever poison had passed into the water of the well, which was so low that the dilution would not be great.

Miss ——, who was assisting her mother nurse the sick family for a few days, went home Nov. 12, and became ill with typhoid-fever on the 24th; the mother followed to take care of her a few days later, and herself came down, Dec. 7, with the disease, and another daughter Dec. 14. Four others in the house escaped. There seemed no way of explaining these three cases, none of which were fatal, except by contagion, they all having been exposed to the concentrated poison of the air in a small house containing seven persons very ill with typhoid-fever, and not having drank any of the well-water.

It seems clear that water contaminated with the dejections of typhoid-fever patients is so certain a poison that it can be taken into the system only with the greatest danger.

TYPHOID-FEVER. — TWELVE CASES FROM ONE WELL.

Whether or not well-water contaminated with filth not containing the specific poison of any disease may, under certain conditions and in certain cases, produce any of the specific diseases, the evidence is conclusive that the danger in drinking such polluted water is greater than it would be safe to assume.

In a case reported by Dr. F. T. Vinal of Scituate, the well was only thirty feet from the privy-vault, in lower ground, and in the direction of the water-shed. The privy was full until Sept. 12, when the contents were removed, and the vault was filled with lime and earth; the soil was loam, sand, and gravel, and the general direction of the water-shed southerly.

During July, Mr. and Mrs. ——, the occupants of the house, were both ill with diarrhœa. Aug. 24, Mr. —— went to bed with typhoid-fever; Sept. 7, one son; Sept. 16, another son, and a farm-hand; Sept. 17, the third son; Sept. 19, Mrs. ——, the cook, and another servant, — in all comprising the whole household. Between Sept. 8 and 14, three neighbors who drank the same water, and a nurse of the first man sick also, became quite ill with the same disease. None of the cases were fatal.

Only three other persons, a mile from the house just sketched, and a neighbor who had attended the sick people (the last as late as Oct. 27), had typhoid-fever during the summer in the town. These people did not drink the polluted water, and their sickness is not accounted for by Dr. Vinal, unless possibly in one case at least (the nurse) by contagion.

The well was pumped dry nearly every day for a month after Sept. 22, and therefore, at the time of examination, Oct. 18, the water was, of course, very much better than when the illness occurred. It contained bacteria and infusoria, and in parts per 100,000: —

Ammonia	0.003
Albuminoid ammonia	0.013
Inorganic matter	4.3
Organic and volatile	.7
Total solids	5.0
Chlorine	1.0

The residue blackened on ignition. The amount of albuminoid ammonia is very high for well-water, and the presence of bacteria indicates the presence of decaying matter. Probably the chlorine found is normal at that distance from the sea. Undoubtedly the well-water was very much contaminated at the time of the fever.

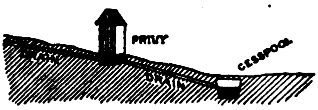
TYPHOID-FEVER, ETC. — BAD DRAINAGE.

Dr. Stow of Palmer reports typhoid dysentery in one woman, diarrhœa and fever in her daughter, and fever, with a brown tongue and diarrhœa, in another daughter, son, grandson, and servant, comprising all the family. The previous occupants of the tenement, three in number, all had typhoid-fever. Of the people living in the other half of the same house, the mother had typhoid-fever, and the children had scarlet-fever in its worst form, — two dying and two recovering. On examination of the cellar, the drain used by the two families was found all open, and very offensive; it had been so since early spring. This drain emptied into a moist piece of land, about fifty feet from the house, on the north side. The well was situated back of the house, about ten feet distant, — the privy not more than thirty feet from the well, and on higher ground.

SCARLET-FEVER AND DIPHTHERIA.

Dr. Hodgdon of Arlington reports as follows: —

I have seen two private families within the year in which defective drainage seemed to play an important part in cases of severe scarlatina and diphtheria. In both the defect was sought for, found, and remedied in the course of the disease. In each case there was a privy near the house, the privy-vault being cemented at the bottom, and the house-drain from kitchen and bath-room running



through it. It was expected that the water from the house would wash the vault clean; but the outlet from the vault became clogged, and the vault soon filled, and closed the inlet; and as there was no trap outside the house in the drain, the gases from the decomposing mass in the vault were easily forced through the traps inside the house, — the inside traps having no ventilation. In one family there were five cases of diphtheria, and one death, and one severe case of scarlatina. In the other house, all the children, three in number, had scarlatina, with diphtheritic throats, two of the cases being fatal.

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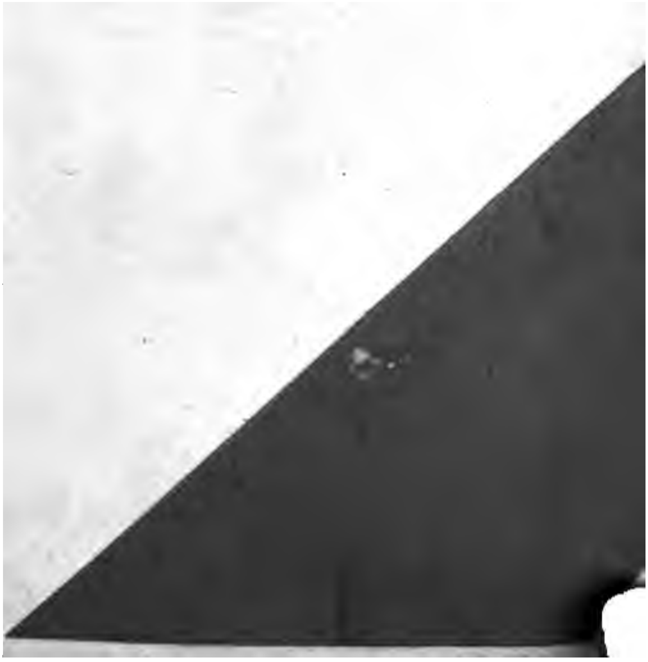

NAME	DATE DUE
	3469